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Food Selection by Canada Geese During Fall Staging on the Nisutlin River Delta, Yukon Territory

by

(C) Timothy S. Coleman

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science

Department of Zoology

EDMONTON, ALBERTA

Spring 1985

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Date.....January 24/85.....

Abstract

Food selection by Canada geese (*Branta canadensis*) staging in the autumn on the Nisutlin River delta in the south-central Yukon Territory was investigated from August to October of 1981 to 1983. Relative benefit to the geese of two different food types was examined in terms of weight gain.

Preferred feeding zones were determined by observation of the feeding habits of wild Canada geese staging on the delta each autumn. An aquatic zone in which *Potamogeton richardsonii* rhizomes were eaten by geese was preferred over a terrestrial, vegetatively-complex zone where *Equisetum palustre* was the main plant taken, and this latter was preferred over pure stands of *E. fluviatile*. Availability of these feeding zones was associated with water levels on the delta. When water levels were low (October 1982), *P. richardsonii* rhizomes were obtained by the geese through "cratering" behavior in the shallow waters of Nisutlin Bay. At these times, all other feeding zones were available yet the geese fed almost entirely in the *Potamogeton* zone. At intermediate water levels, *P. richardsonii* was no longer available and the geese grazed on the complex vegetative zone. At high levels (>4.9 m) (September 1981), the geese were forced to graze exclusively in the *E. fluviatile* zone.

Benefits accruing to geese feeding in the complex vegetative zone were compared with those while feeding on *E. fluviatile* using two groups of tame Canada geese grazing in

these zones over a 14-day period in August, 1983. Rate of intake in terms of bites per minute (BPM) for the two tame groups differed significantly. Those feeding on *E. fluviatile* had a lower rate than those grazing in the complex zone. Despite this difference, the actual dry weight intake by geese in the two groups was the same. Thus, the lower rate of intake among birds feeding on *E. fluviatile* was compensated for by a larger biomass consumed per bite. Weight gain among the geese grazing in the complex zone was significantly greater than for those grazing on the *E. fluviatile*. Thus, greater benefits accrued to geese feeding on the more preferred vegetation.

The four main foods used by the geese were examined for nutrient content. The most preferred *Potamogeton richardsonnii* contained the highest levels of non-structural carbohydrates as well as the lowest fiber and crude protein content. Analysis of feces produced by geese feeding in the complex zone (mainly on *E. palustre*), and on *E. fluviatile* showed the geese were assimilating more carbohydrates from the former than the latter. *Hippuris vulgaris*, a relatively minor food item of the geese, had the highest fiber content and the lowest % dry weight carbohydrate. These results suggest that Canada geese, on fall staging areas, are selecting for carbohydrate content and potential carbohydrate digestability rather than protein content. Despite differences in nutrient content of the major foods in the shoreline vegetation, the gut measurements of the two

groups of tame Canada geese showed no apparent differences, probably because the amounts eaten per day were similar in the two groups.

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I would like to acknowledge the guidence and assistance of my supervisor, Dr. David Boag. If he had not given me the opportunity to embark upon this project the document in hand would not be in existance. His critical reading and editing of the manuscript was an invaluable aid.

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Table of Contents

Chapter — Page

I. INTRODUCTION 1

II. STUDY AREA 5

III. FOOD SELECTION BY CANADA GEESE 10

A. Introduction 10

B. Methods 11

C. Results 15

Vegetative Zones 15

Foraging Behavior 17

Water Levels 21

Area of Zones 24

Relationship Between Zones of Vegetation Used and Water Levels 24

D. Discussion 29

Modification of Food Preferences 29

Other Factors Related to Food Preferences ..31

Switching Diets 34

Average Year Use 34

IV. NUTRITIONAL VALUE OF FOODS USED BY CANADA GEESE ..36

A. Introduction 36

B. Methods 38

Relative Benefits 38

Nutritional Analysis 41

C. Results 43

Relative Benefits 43

Nutritional Analysis 49

D. Discussion 52

Relative Benefits 52

Nutritional Analysis 56

V. GUT MORPHOLOGY OF CANADA GEESE ON DIFFERENT DIETS 61

A. Introduction 61

B. Methods 62

C. Results 63

D. Discussion 67

Weights 67

Lengths 67

VI. CONCLUDING DISCUSSION 69

VII. LITERATURE CITED 74

VIII. APPENDIX I 80

LIST OF TABLES

Table	Description	Page
1.	Observational schedule followed when recording activities of the Canada goose population staging on the Nisutlin River delta for the period 1981 to 1983	14
2.	Area of vegetative food zones exposed under high and low water conditions for the period 1981-1983	25
3.	Ingestion rates by two groups of tame Canada geese grazing in two types of vegetation	46
4.	Weights (kg) before and after a 2-week feeding period of two groups of Canada geese fed different diets	48
5.	Fiber, crude protein, total non-structural carbohydrate (TNSC) content (% dry weight) of food plants and feces of Canada geese grazing on the Nisutlin River delta	50
6.	Ranking of goose food plants growing on the Nisutlin River delta according to preference, fiber content, protein content, and TNSC content	53
7.	Comparison of carbohydrate content of goose foods in three different areas	58
8.	Actual and standardized digestive organ measurements of two groups of Canada geese fed two different diets over a 2-week period	64
9.	Proportion of body weight devoted to digestive organs in two groups of Canada geese	66

LIST OF FIGURES

Figure	Description	Page
1.	The Nisutlin River delta, surrounding area, and location within the Yukon Territory	8
2.	Map of the Nisutlin delta study area showing the location of the two observation platforms and the field camp	13
3.	Percentage of all feeding geese in each of three zones of vegetation during the fall of 1981	16
4.	Percentage of all feeding geese in each of three zones of vegetation during the fall of 1982	18
5.	Percentage of all feeding geese in each of three zones of vegetation during the fall of 1983	19
6.	Feeding zones and resting areas used by Canada geese while staging on the Nisutlin River delta, relative to the permanent and low water (recorded in October 1982) shorelines 1981-1983	20
7.	Water levels at Teslin, Yukon Territory for the fall period of 1981-1983 and the 10-year mean (1973-1983)	22
8.	Shorelines observed at high and low water on the Nisutlin River delta during the fall period 1981 to 1983	23
9.	Relationship between use of the *Potamogeton* vegetative zone and water levels on the Nisutlin River delta, 1981-1983	26
10.	Relationship between use of the Complex zone and water levels on the Nisutlin River delta, 1981-1983	27
11.	Relationship between use of the *Equisetum* zone and water levels on the Nisutlin River delta, 1981-1983	28
12.	Proportion of geese feeding in the *Potamogeton* zone versus the Complex zone on the Nisutlin River delta, 1981-1983	30
13.	Feeding areas grazed by the two experimental flocks of Canada geese, Nisutlin River delta, August 1983	40

14. Feeding rate in bites per minute, over a 10-hour period, for three groups of Canada geese. 44

15. Average daily cumulative weight changes shown by the members of two groups of Canada geese, one feeding in zone A and the other in zone B for a 2-week period.....47

LIST OF PLATES

Description

Plate		Page
1.	The Nisutlin River delta	9
2.	The Nisutlin River delta	9

I. INTRODUCTION

The importance of fall and spring staging along the migration paths of geese has only recently been appreciated in studies of waterfowl ecology (Delta Report 1982). It has been suggested that the nutrients obtained during time spent on spring staging areas are critical to the timing and success of breeding in goose populations (Ankney 1977, Newton 1977). The nutritional benefits derived on the breeding and wintering areas have been studied in some detail by Derksen *et al.* (1982). General body condition of geese arriving on the wintering grounds may reflect the nutritional benefits gained while on fall staging areas. In this respect, the importance of nutrition on the fall staging area may be carried over into winter and the following spring and hence influence the breeding success of geese.

Herbivores often exhibit preferences for particular plant types and select them from available foods while foraging. Moss (1972) and Westoby (1974) have shown that selection can be related to the nutritional content of the chosen foods, yet others have shown no such relationship (Taylor 1957). The critical component in food selection may be either nutritional or relative availability (Owen 1972a). However, it has also been suggested that the avoidance of plant secondary compounds rather than nutrient content may

affect selection of food items (Bryant and Kuropat 1980) and according to Klein (1970,1977) and Harper (1977) , plant palatability may also influence the selection of forage by grazing herbivores.

Canada geese (*Branta canadensis*) have attributes that make them well suited for a study of foraging ecology. When concentrated on a staging area, they are usually visible and can be easily observed. It is possible to observe the types of plants being taken by the geese as well as examine the physical evidence left by the birds in the feeding area (Owen 1980). This evidence may include marks on the plants used and the absence of parts of the plants selected. Food preferences may also be recorded at a grosser level through recording particular plant communities chosen for feeding. The geese generally forage as a flock and their time budgets can be easily recorded. Because the timing of feeding and loafing in these birds follows a regular pattern (Burton and Hudson 1978), it is possible to predict the appropriate time of day for observing foraging behavior. Futhermore, because geese can be imprinted to human observers (Hess 1964), it is possible to follow closely and observe tame geese while they graze in selected plant communities that are also used by the wild geese in the area. It is possible to measure the relative benefits of each food type to groups of tame geese grazing on different plants by recording weight changes over a period of time.

In the southern Yukon, fall staging areas for waterfowl are very few in number. This is related to the topography of the region and the lack of suitable habitat. Most of the Yukon River basin in this area consists of mountainous bedrock bluffs and deep valleys (Hunt 1974). Because there are very few suitable waterfowl staging areas in the Yukon, populations tend to concentrate in those available.

Very little is known about where the populations of Canada geese using fall staging areas in the southern Yukon winter and breed. Using a limited set of measurements (see Appendix I), compared with a set of measurements found in Owen (1980), the populations staging in the southern Yukon appear to belong to the following subspecies: *Branta canadensis occidentalis*. An extensive set of measurements are now in possesion of the Department of Renewable Resources in Whitehorse, Yukon Territory.

The Northern Canada Power Commission (N.C.P.C.), in its report on the development of power in the Yukon (1975), identified the Teslin River, which drains Teslin Lake, as a potential site for hydroelectric development. If such development occurred, the water levels on Teslin Lake might be affected to the extent that the Nisutlin River delta could be obliterated. Such changes to water levels and the concomitant loss of habitat would undoubtedly affect waterfowl populations staging there. These factors lend added importance to this study of the ecology of the Canada geese using the area.

No in-depth study of critical habitat and waterfowl use has been done in the area before this one and, if the proposed hydroelectric development occurs, the loss to waterfowl populations in the Yukon is a potential consequence. No further studies of this productive wetland area would be possible in the event of such developments.

In July, 1982, I began a study of the foraging strategies and nutritional benefits derived by a population of Canada geese using the Nisutlin River delta in the southern Yukon as a fall staging area. This study addressed the following questions:

1. What foods are used by the geese while staging on the Nisutlin River delta and are some preferred over others?
2. How are food preferences affected by availability?
3. On what basis are foods selected by the geese?
4. What are the relative benefits obtained by the geese from each food type?
5. Did the characteristics of the gut change in response to different foods used by the geese?

These questions are examined in the following three chapters of the thesis.

II. STUDY AREA

The study area, a delta at the mouth of the Nisutlin River (60°12'-60°15' N, 132°35'-132°39' W), is located 12.5 kilometers East North East of the settlement of Teslin in the southern Yukon (Fig. 1). The elevation of the delta is approximately 600 m asl, with the surrounding mountains ranging up to approximately 1500 m. The valley of the Nisutlin River is typical of older river valleys in terms of stream development; shallow cutoffs, oxbow lakes, and numerous sloughs are present along the lower reaches. The river drains an area of some 8030 km² and its spring through fall discharge ranges from 18.9 m³ to 541 m³ per sec. (Environment Canada 1981). The river carries silt downstream during the spring and early summer and this contributes to the formation of sediment deposits at its mouth in Nisutlin Bay on Teslin Lake. With falling water levels over the course of the summer and fall, these sediment deposits are exposed as mud flats in the delta area. Extensive vegetative growth occurs on these flats as well as in the waters of the bay adjacent to them.

Vegetationally, the areas surrounding the delta itself are dominated by mixedwood forests of aspen (*Populus tremuloides*) and balsam poplar (*P. balsamifera*), black spruce (*Picea mariana*), and lodgepole pine (*Pinus contorta*).

This forest becomes primarily coniferous at higher elevations. The islands in the delta are dominated by balsam poplar and willow (*Salix* spp.), with *Rosa* sp. and *Equisetum* spp. composing a large portion of the understory. *Viburnum opulus* and *Viburnum edule* can also be found commonly in this area as well as several species of club mosses (*Lycopodium* spp.). The mud flats, where the Canada geese do much of their foraging, are dominated by a variety of perennials. *Equisetum palustre* as well as *E. fluviatile* are important species along with several species of buttercup (*Ranunculus* spp.). *R. reptans* appears to be the most important to geese. Widespread growth of *Eleocharis palustris* occurs on the mud flats as do extensive stands of *Carex aquatilus*. Patchy growth of *Juncus* sp., *Hippuris vulgaris*, and *Sparganium* sp. can also be found in patches on the mud flats. Clumps of other graminoid species such as *Poa* sp. and *Agrostis* sp. are found scattered throughout the area but these plants appear to be of minor importance to the foraging geese. Vegetation in the surrounding waters of the bay include: water-milfoil (*Myriophyllum alterniflorum*), *Hippuris vulgaris*, *Potamogeton richardsonii*, *P. pectinatus*, and *P. filiformes* . *P. richardsonii* appears to be the most important aquatic plant for the geese. Nomenclature is according to Hulten (1968), Hitchcock and Conquist (1973) and Budd (1973).

The only access to the study area is by boat from Teslin or a point some 150 kilometers upstream of the delta. At one time, logging activities were carried out along the

lower Nisutlin River and some of the delta channels were modified to some extent by this. These activities ceased in the early 1970's and very little evidence of them remains on the area. In the natural state, the delta is in a constant state of change, most of which occurs with the spring flooding and subsequent fluctuation in water levels over the summer and fall.

Plates 1 and 2 provide an aerial view of the delta on 21 September, 1981 when water levels were among the highest recorded during the 3 years of this study.

The Nisutlin delta is recognized as one of the most important fall staging areas for waterfowl in the southern Yukon (Geist *et al.* 1974, Hoefs 1976). Very few waterfowl nest on the delta (Can. Wildl. Service unpublished observations, this study). This may partly be due to the high spring water levels resulting in a lack of suitable waterfowl nesting habitat. Nisutlin Bay has been proposed as an International Biological Program (I.B.P.) site (Geist *et al.* 1974) and as a National Wildlife Area (Can. Wildl. Service 1977). The Department of Renewable Resources of the Yukon Territorial Government has recommended that the area be given the status of "Critical Wildlife Habitat Area", under which wildlife management would have a high priority (Hoefs 1976). Because the delta is a traditional hunting area for the local native people of Teslin, it may be considered in the settlement of land claims in the Yukon.

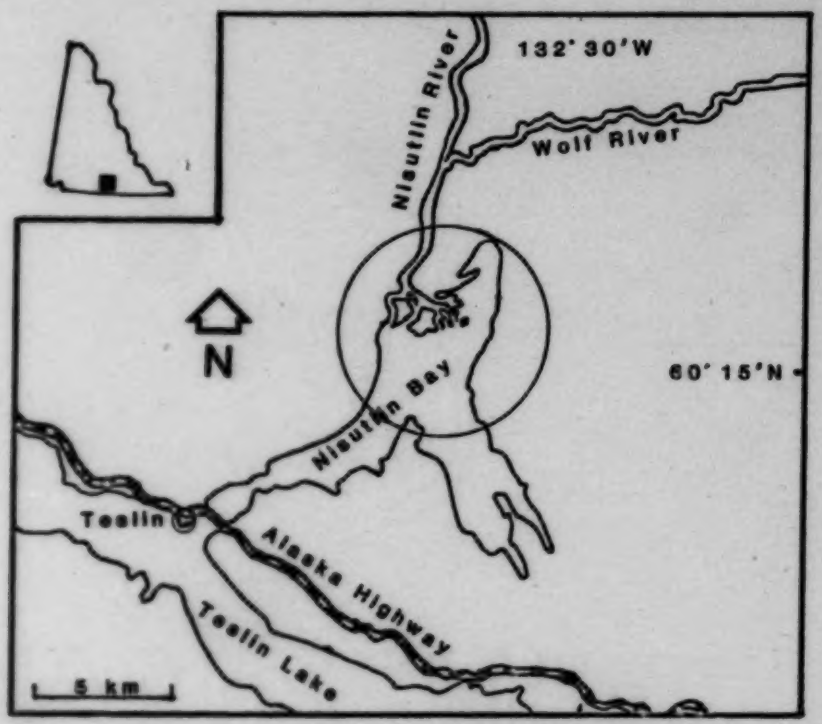

Figure 1. The Nisutlin River delta, surrounding area, and location within the Yukon Territory.

Plate 1. The Nisutlin River delta.

Plate 2. The Nisutlin River delta.

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Images en couleur

III. FOOD SELECTION BY CANADA GEESE

A. Introduction

Examples of food selection can be found in many browsing herbivores such as moose (*Alces alces*) (Berg and Phillips 1974, Krefting 1974, Bevlovsky 1978), deer (Aldous 1952, Klein 1970, Radwan and Crouch 1974,1978), lagamorphs (Miller 1968, Lindlof *et al*. 1974, Bryant and Kuropat 1980), grouse (Moss 1972, Pulliainen and Salo 1973), and beavers (*Castor canadensis*) (Jenkins 1975, Skinner 1984), and grazers such as domestic sheep (Caldwalladr and Morley 1973, Arnold 1960).

It is generally accepted that geese may also show some selectivity for food types. Owen (1971) reported that wintering white-fronted geese (*Anser a. albifrons*) selected particular vegetation zones within a salting pasture. Selection for certain plants was also found in dark-bellied brent geese (*Branta b. bernicla*) (Charman and Macy 1978). Lieff *et al*. (1970) determined that immature geese of two species at McConnell River, Northwest Territories were selecting for particular foods when a number of choices were available. Food selection by lesser snow geese (*Anser c. caerulescens*) has been shown to occur on fall staging areas in the James Bay region as well (Prevett *et al*. 1979).

Food selection by geese has been studied to a greater extent on breeding and wintering areas than moulting and

staging areas (Fredrickson and Drobney 1979). In the past few years, staging areas have become of interest to investigators of waterfowl ecology (Delta Report 1982) because of their importance to waterfowl during migration (Ankney 1977, Wypkema and Ankney 1979, Gauthier *et. al.* 1984). The Nisutlin River delta is one of the most important fall staging areas in the Yukon Territory (Geist *et al.* 1974).

Factors affecting access to feeding areas and hence food selection by geese include harsh weather conditions (Phillipona 1966), disturbance by man (Owen 1972b), and changing water conditions (Murdy 1966, Smith 1970, Brewster *et al.* 1976). Most of these studies were done on breeding areas. Blue-winged teal (*Anas discors*) were found to switch diets when fluctuating water levels caused certain food types to become unavailable (Swanson and Meyer 1977).

Canada geese (*Branta canadensis*) staging on the Nisutlin River delta in the fall may show food selectivity, preferring to feed in certain vegetation zones. This selection may be modified by fluctuating water levels on the delta. This chapter reports on food selection by these geese and the impact of such fluctuations in water levels on the foraging characteristics of the geese.

B. Methods

This study of food selection was initiated in the fall of 1981 and continued through the 1982 and 1983 staging periods. The foraging behavior of the Canada geese was

observed from two vantage points on the delta (Fig. 2). The main observation point, overlooking Nisutlin Bay, was a 5 m tower with a camouflaged blind at the top. The geese were observed through a 25-40 power spotting scope. Observations involved regular 180° scans over the delta, recording the location, on a map of the delta, of each group of geese present and their behavior whether feeding or loafing. The secondary observation platform, a bench-like structure located approximately 3 m high in the forked crown of a pine tree, overlooked Colwell Bay. Here the geese were observed through 8x30 binoculars using a 270° scan. In this way, numbers, positions, activities, and foods used by the geese on the delta for the 3 years were recorded.

High level aerial photographs of the delta were used to produce a 1:20000 map of the area, which was used throughout the study for plotting the positions of the geese, the various vegetation zones, and the changing position of the shoreline on the delta.

I maintained a schedule of observations which was followed as light permitted and covered the entire daylight period (Table 1). This enabled me determine activities of the geese throughout this period. Vegetation zones used were based on observations from the blinds and subsequently confirmed by going onto the delta on foot. By comparing availability of vegetation, as the result of fluctuations in the water levels, with patterns of use by the geese, it was possible to determine which zones of vegetation were

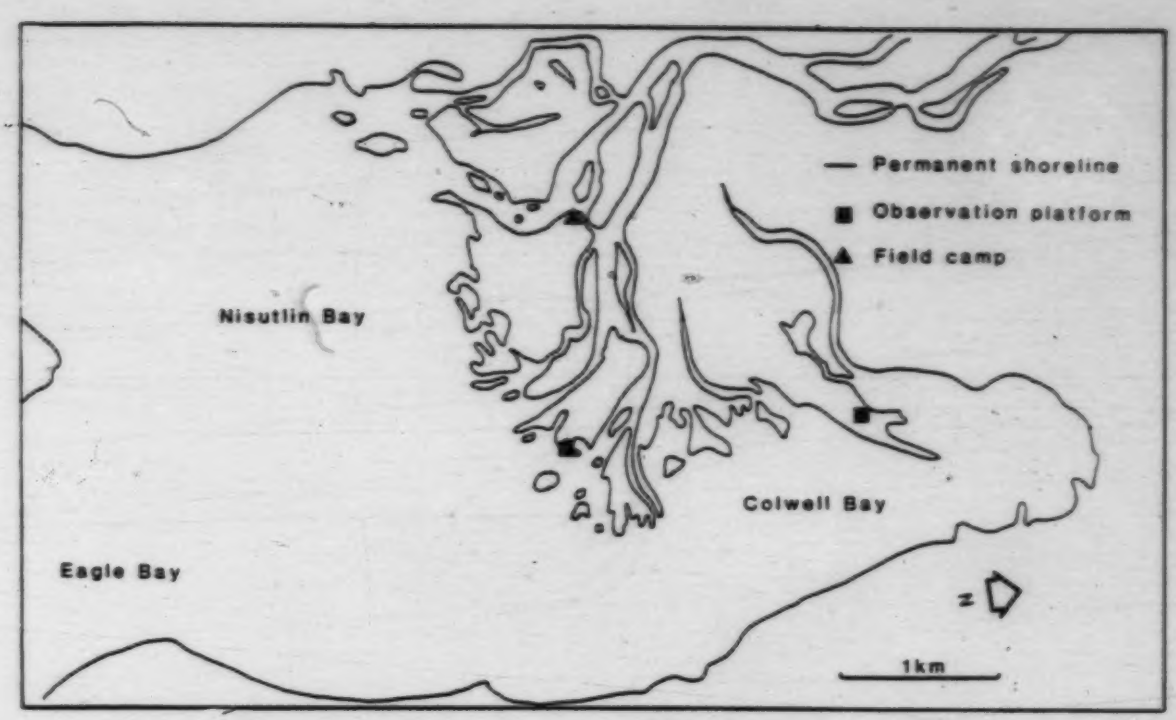

Figure 2. Map of the Nisutlin delta study area showing the location of the two observation platforms and the field camp.

Table 1. Schedule of observations followed when recording the location and activities of Canada geese staging on the Nisutlin River delta for the autumn period of 1981 to 1983.

Day	Main Tower	Colwell Platform
1	0600-0700	0800-0900
2	2000-2100	1800-1900
3	1100-1200	1300-1400
4	0800-0900	0600-0700
5	1800-1900	2000-2100
6	1300-1400	1100-1200
7	0900-1000	0700-0800
8	1700-1800	1500-1600
9	1500-1600	1700-1800
10	0700-0800	0900-1000
11	2100-2200	1900-2000
12	1400-1500	1600-1700
13	1900-2000	2100-2200
14	1600-1700	1400-1500
15	1200-1300	1000-1100
16	1000-1100	1200-1300
17*		

* Repeat from day 1.

preferred. The area of the zones of vegetation exposed during fluctuations in water levels was determined by placing a 1 ha grid over the 1:20000 map on which the vegetative food zones were drawn in under both high and low water conditions. Water levels at Teslin, which are reflected on the delta, were taken at a continuous recorder station at Teslin by the Department of the Environment and published by Environment Canada.

Analyses of water level and food habit data were done through regression analysis and analysis of variance subprograms of the MINITAB statistical package. Procedures for running this package can be found in Ryan *et al.* (1976).

C. Results

Vegetative Zones

Three zones of vegetation were used regularly by the Canada geese during autumn while staging on the Nisutlin River delta over the 3 years of the study. They included:

1) One zone consisting almost exclusively of *Equisetum fluviatile*. This zone, located in wet depressions behind natural levees, was used only slightly in 2 years but heavily only in 1981 (Fig. 3).
2) A second zone of a greater plant diversity which I refer to as the "complex" zone, supported three species of plants that were important to

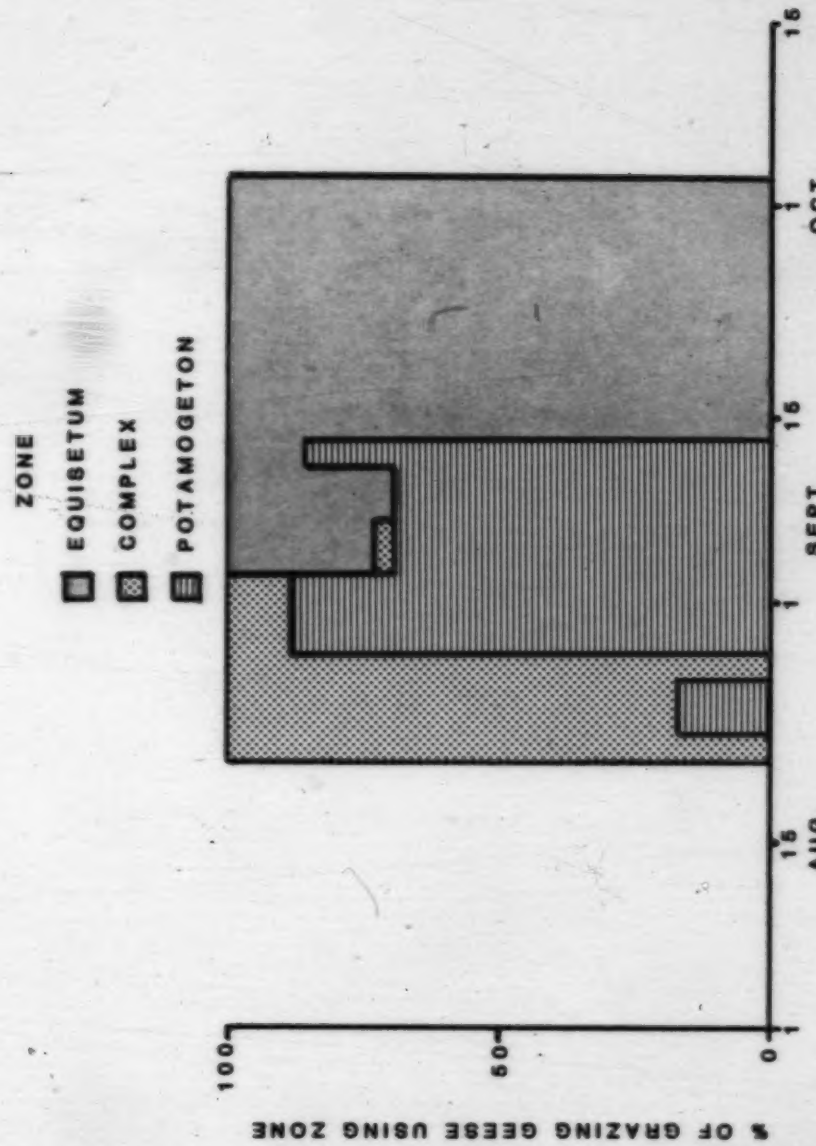

Figure 3. Percentage of all feeding geese in each of three zones of vegetation during the fall of 1981.

the geese *Equisetum palustre* (85% of the diet), *Ranunculus reptans* (10% of the diet), and *Eleocharis palustris* (5% of the diet). This zone was grazed to a considerable degree in all years of the study (Figs. 3,4,5).

3) The third zone was under water with the aquatic plant *Potamogeton richardsonii* being the species most often eaten. The geese appeared to root in the sediments and take only the underground rhizomes of this plant. Other species of *Potamogeton*, located in the same zone, were apparently used little by the geese. This zone was used during all three years of the study but most particularly in 1982 (Fig. 4).

Foraging Behavior

Grazing of the various zones of vegetation, and consequently foods used by the geese, varied among years as well as within seasons (Figs. 3,4,5). The geographical relationship of these zones to the island used by resting geese is shown in Figure 6. The foraging behavior of the geese changed concurrently with the zone of vegetation used. When feeding on the *Equisetum* zone, the geese had to fly between 2.7 and 4.3 km to and from the feeding and resting areas (Fig. 6). This flight usually carried them over those parts of the delta dominated by willows, whereas when using the complex zone, the geese had a shorter distance to fly

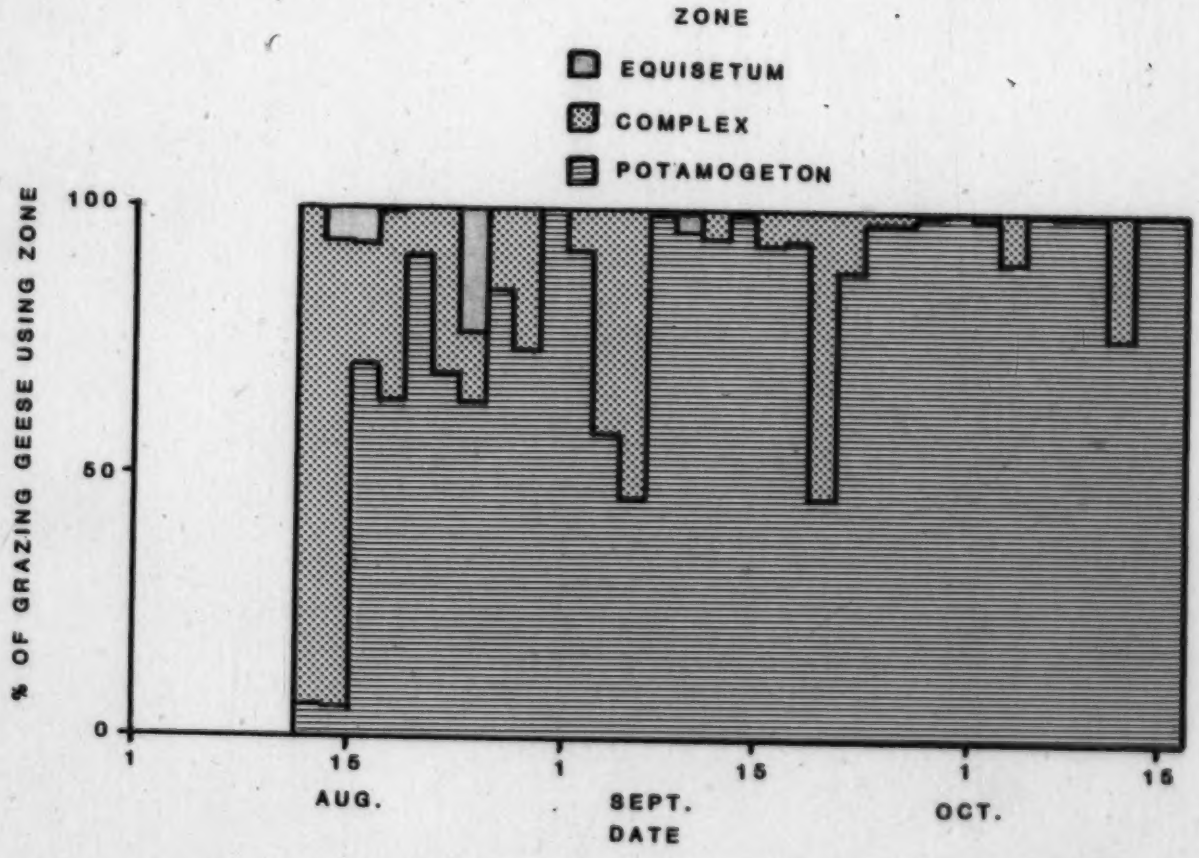

Figure 4. Percentage of all feeding geese in each of three zones of vegetation during the fall of 1982.

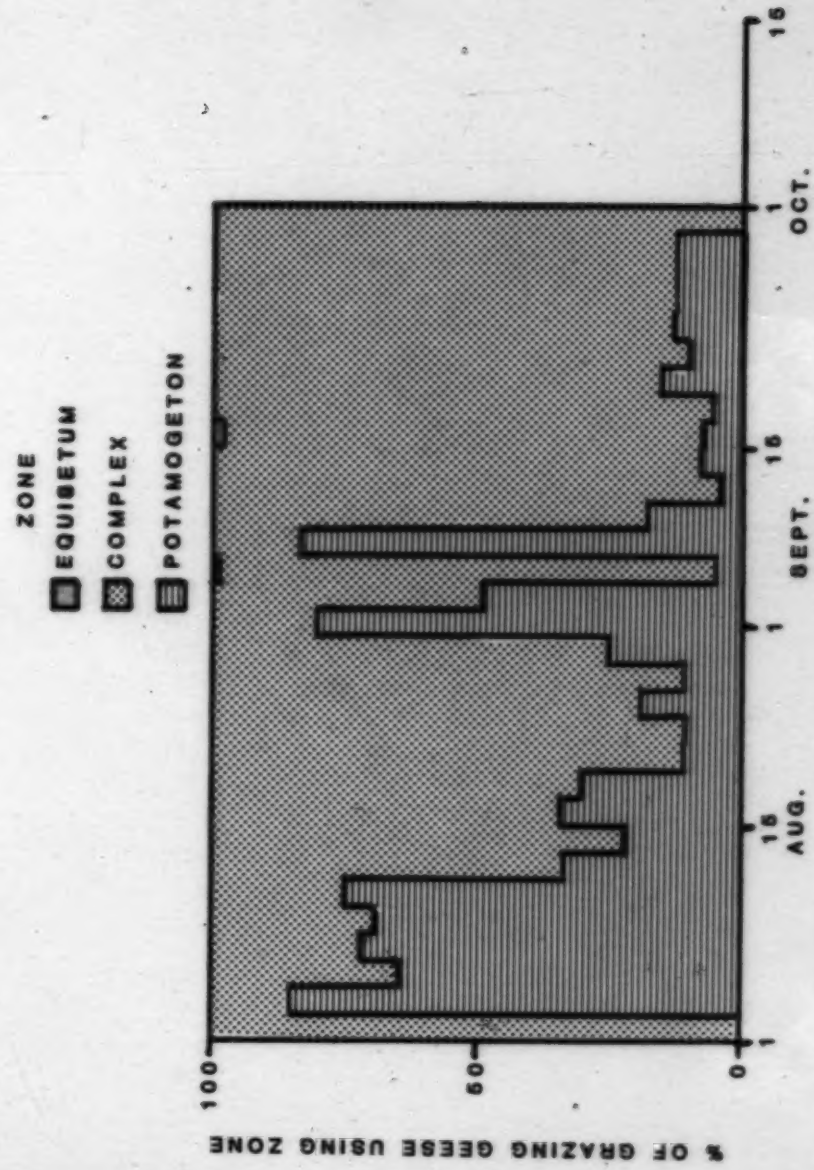

Figure 5. Percentage of all feeding geese in each of three zones of vegetation during the fall of 1983.

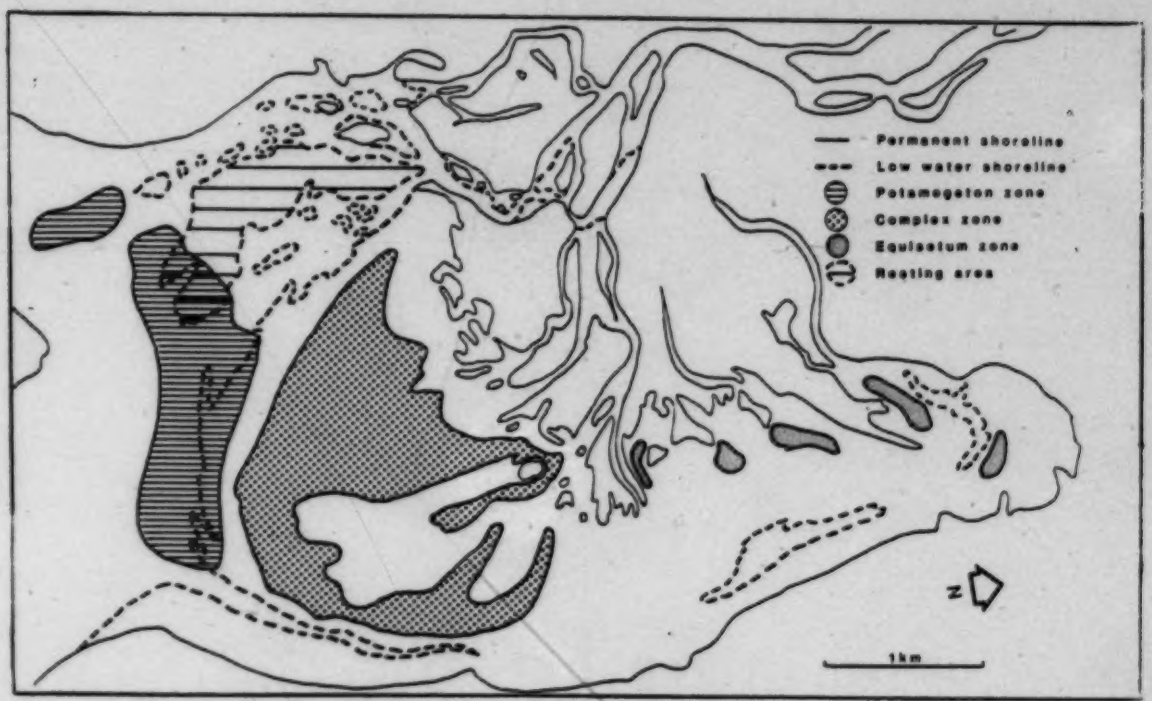

Figure 6. Feeding zones and resting areas used by Canada geese while staging on the Nisutlin River delta, relative to the permanent and low water (recorded in October 1982) shorelines 1981-1983.

(0.7 to 3.2 km), and their flight paths generally skirted the willows. When feeding on the *Potamogeton* area, their flights were direct and often shorter (0 to 2.3 km).

The geese, when grazing on the *Equisetum* and complex zones, would grasp a portion of the desired vegetation in the bill and, with a sharp upward jerking motion, break it off and ingest it. As was the case in a study reported by Kuyken (1969), the geese did not uproot the plants they were grazing upon. By contrast when feeding in the *Potamogeton* zone, the geese engaged in "cratering" behavior. They would tip up in the shallow water and dig in the sediments with their bill until a portion of rhizome was encountered by the bill tip, whereupon it was pulled up and ingested.

Water Levels

Water levels on the delta also varied over the 3 years (Fig. 7), reflecting differing amounts of precipitation (Environment Canada 1981-1983). During 1981, the water levels fluctuated over the season from a low of 4.392 m on August 30 to a high of 5.022 m on September 24 and 28 (Fig. 7). Shorelines associated with high and low water level readings in autumn can be seen in Figure 8. During low water in October 1982, an estimated 1365 ha of mud flat area were exposed beyond what was exposed the previous spring. At fall high water levels (September 1981) an estimated 464 ha of delta were exposed. After September 28, water levels fell somewhat (Fig. 7) but generally did not fluctuate to a great

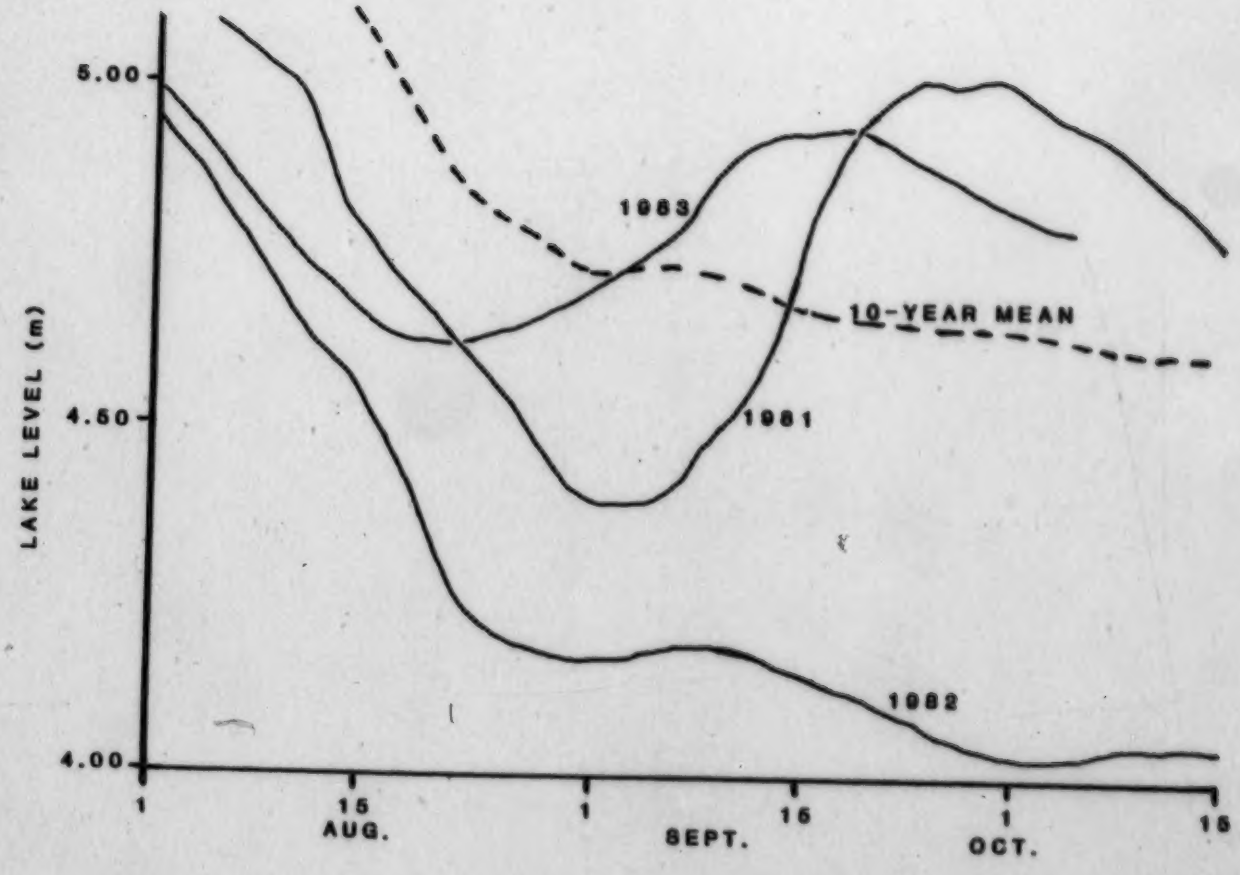

Figure 7. Water levels at Teslin, Yukon Territory for the fall period of 1981-1983 and the 10-year mean (1973-1983).

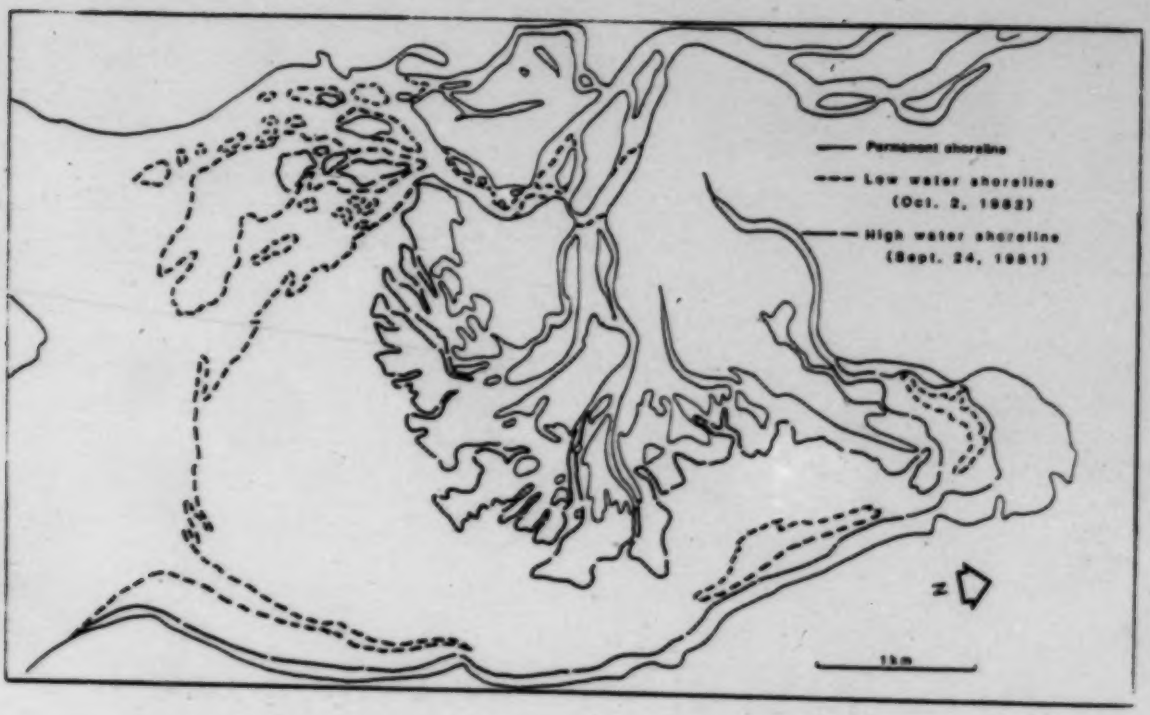

Figure 8. Shorelines observed at high and low water on the Nisutlin River delta during the fall period 1981 to 1983.

degree. In 1983, levels fell to a low of 4.625 m on August 19 and then rose to a high of 4.941 m on September 17.

Area of Zones

The areas of two of the three vegetation zones available for use by the geese varied as water levels fluctuated (Table 2). The area of *Potamogeton* available to the geese was dependent upon water depth over the areas where *P. richardsonii* grew. I found the geese used this vegetation when overlying water depths varied between 0.1 and 0.5 m. Kiorboe (1980) found *P. pectinatus* growing in water of 0.14 to 0.74 m with the highest biomass at the 0.57 m depth; waterfowl use of this plant was also related to overlying water levels.

Relationship Between Zones of Vegetation Used and Water Levels

The proportion of geese using a given vegetative zone was plotted against the water levels at that time. Data for all 3 years were combined (Figs. 9, 10, 11). Use of the *Potamogeton* zone was negatively correlated with water levels ($r=-0.75$, $P<.001$). As water levels dropped, use of this zone increased (Fig. 9). Use of the complex zone was also correlated with water levels ($r=0.53$, $P<.002$) (Fig. 10), but in a curvilinear manner, with the greatest amount of use occuring at intermediate water levels (4.6 to 4.9 m). By contrast, use of the *Equisetum* zone appeared to be

Table 2. Area of vegetative food zones exposed under high and low water conditions for the autumn period 1981 to 1983.

	Area in ha	
Vegetative zones	Low water	High water
Potamogeton	138	0
Complex	250	31
Equisetum	29	29

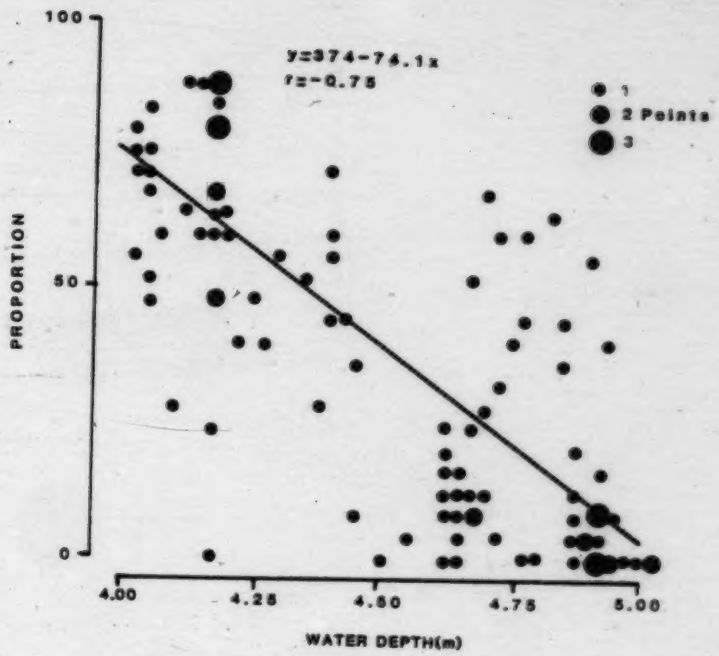

Figure 9. Relationship between use of the *Potamogeton* zone and water levels on the Nisutlin River delta, 1981-1983.

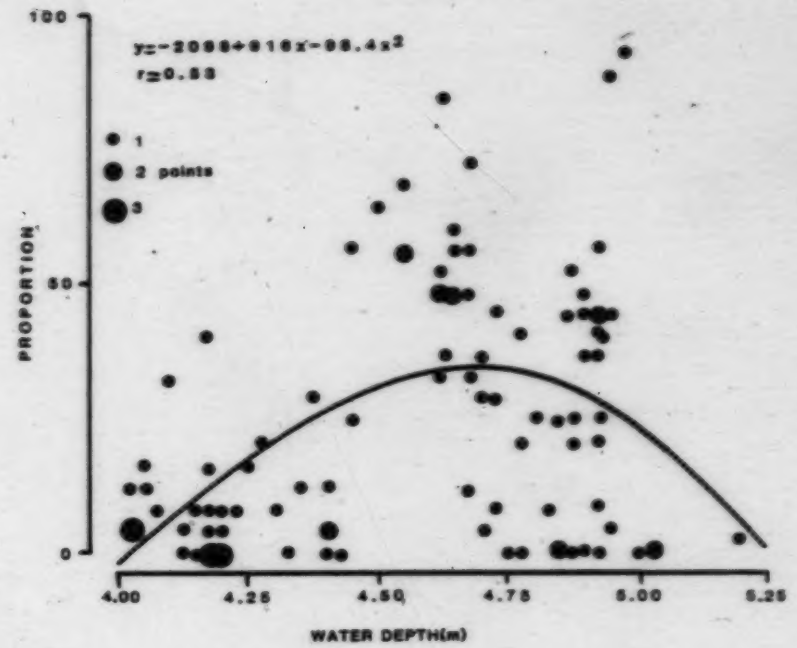

Figure 10. Relationship between use of the Complex zone and water levels on the Nisutlin River delta, 1981-1983.

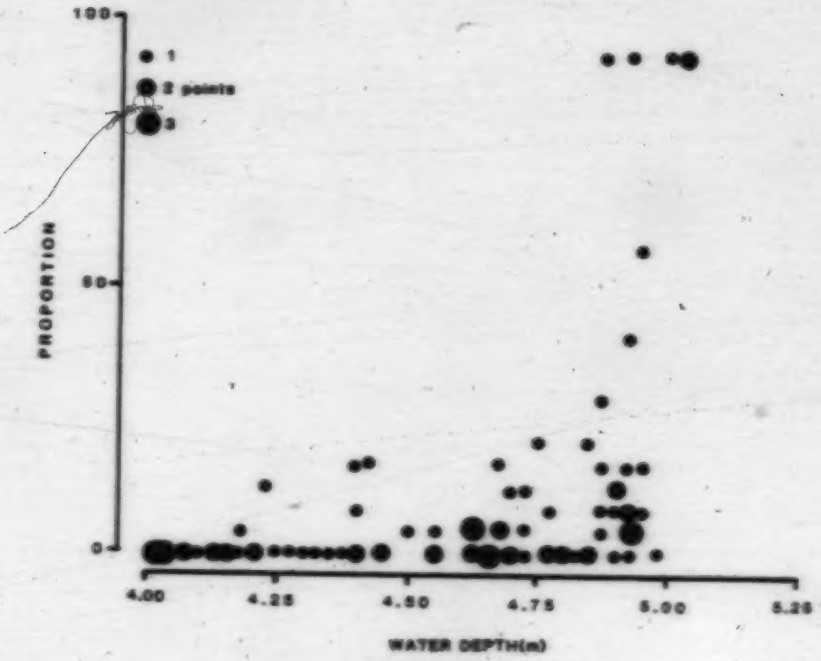

Figure 11. Relationship between use of the *Equisetum* zone and water levels on the Nisutlin River delta, 1981-1983.

positively related to water levels but remained relatively unimportant under most conditions, experiencing a quantum leap in importance to the geese when water levels approached 5.0 m (Fig. 11).

Because the *Potamogeton* and complex zones appeared to be the most important feeding areas on the delta, I investigated the relationship in use between them (Fig. 12). A negative correlation ($r = -0.77$, $P < .001$) suggests that they were the preferred zones, one being used when the other was not available. Since the *Potamogeton* zone was used when the complex zone was also available, but not the converse, the rank of preference appears to be: *Potamogeton*, complex, *Equisetum*.

D. Discussion

Modification of Food Preferences

The food zone preferences exhibited by the population of Canada geese staging on the Nisutlin River delta were apparently modified by availability of the zones. Availability was dependent upon water levels on the delta. Owen and Kerbes (1971:119) state that "real preferences can only be claimed when food was available on all zones". In the case of the Nisutlin River delta all zones were available when water levels were at their lowest point (September of 1982). When water levels at the Teslin recorder station were less than 4.4 m and the geese fed mainly on the

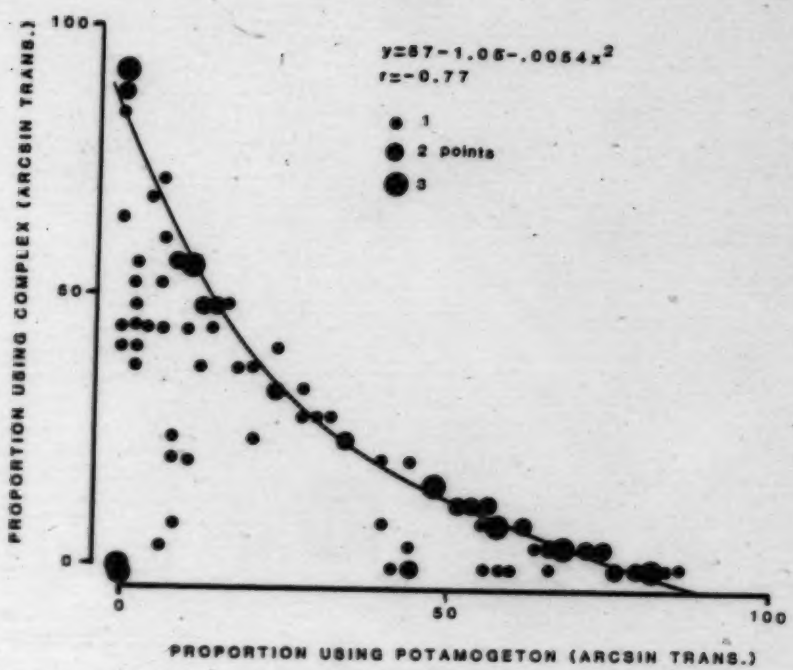

Figure 12. Proportion of geese feeding in the *Potamogeton* zone versus the Complex zone on the Nisutlin River delta, 1981-1983.

Potamogeton zone despite the availability of the other zones (Fig. 9). Because of this, the *Potamogeton* zone appeared to be the most preferred by the geese. When water depths were intermediate (from 4.4 to 4.8 m), the vegetation in the complex zone is of increased importance as goose food. As water levels increase to these readings the *Potamogeton* zone becomes more difficult to reach and the geese appeared to turn to less preferred food types. With the increase of water levels to above 4.8 m, the geese were seen to feed mostly in the *Equisetum* zone (Fig. 11). Thus, fluctuating water levels affected the choice of foods eaten by the Canada geese staging here.

Other Factors Related to Food Preferences

Foraging behavior differed when the geese were feeding in different zones of vegetation. Flights to the less preferred areas were longer than to the more preferred zones and more hazardous, exposing the birds to greater dangers from avian predators, such as bald eagles (*Haliaeetus leucocephalus*) which patrol the delta during the fall, and waterfowl hunters who concentrate at this time in the patches of willow over which flights pass to the *Equisetum* zone (Fig. 6). As more energy would be used in the longer flights to the less preferred areas, this may also be a factor influencing choice of feeding site. Owen (1972b) found that white-fronted geese usually fed within 2 km of the roost site. The *Equisetum* zone on the Nisutlin delta is

beyond this distance while the other two zones are within this range. The most preferred zone could be entered with very little movement from the resting area, being adjacent to it (Fig. 6). The complex zone can also be easily reached but using it may expose the geese to a greater predator risk than feeding in the *Potamogeton* zone because of added potential vulnerability to predators such as red fox (*Vulpes fulva*) and wolf (*Canis lupus*).

Distance over which the geese can see an approaching predator may affect the choice of zones of vegetation used (Derksen *et al.* 1982). The least preferred zone (*Equisetum*) on the Nisutlin River delta is composed of thick stands of plants which may grow to a height of 50 cm (Hulten 1968). Under such circumstances the geese may experience difficulty seeing the approach of possible predators and hence prefer the complex zone, located on a flat area of the delta, where the plants generally do not attain a height of much more than 15 cm. Thus, this, as well as the aquatic *Potamogeton* zone, offer considerably greater visibility than the *Equisetum* zone and hence may be chosen more often for this reason.

Handling time may also be a factor influencing preferences for different food types. The "cratering" behavior shown by geese on the most preferred zone increased handling time relative to grazing on the other two zones. In order to obtain the *Potamogeton* rhizomes, the geese had to tip up in the water and dig about with the bill to find the

appropriate plant part. In grazing, geese simply break off vegetation with sharp jerking bites. Thus, "cratering" may be more energetically demanding than grazing. Owen (1972b) concluded that food selection that led to any decrease in uptake must be compensated by an increase in food value of the those selected. In relation to the preferences shown by the geese in this study, it may be that the longer handling time while using *Potamogeton* rhizomes is more than compensated for by greater nutritional value in this food.

Although the complex zone was apparently preferred over the *Equisetum* zone, it is noteworthy that one of the major food plants of the complex area was *Equisetum palustre*. This plant is, however, of much smaller and finer structure than *E. fluviatile* (Hulten 1968) and can be ingested much more quickly (pers. observ.). Prevett *et al.* (1979) found that *E. variegatum* was a major food of snow geese staging at Winisk on Hudson Bay during the fall. This plant too is small and possibly more easily handled than the large, coarse *E. fluviatile*. Thus, different species may be selected differentially because of factors such as ease of handling and/or assimilation.

Distance from the feeding site to water has also been shown to play a role in selection of the feeding zone. Derksen *et al.* (1982) found that moulting geese remained in feeding zones close to water rather than in more attractive zones some distance inland. On the Nisutlin River delta the area apparently most preferred (*Potamogeton*) was in the

waters of the bay. The complex zone varied in distance from water with parts closer to the shoreline than the *Equisetum* zone while others were more distant. Distance of zones from water seemed to have little influence on food selection on this staging area, possibly because the geese were all capable of flight while on the delta.

Switching Diets

Because there is a high negative correlation between use of the *Potamogeton* and complex zones, and because the latter is available when the former is not, I conclude that the geese switch from the complex zone to the *Potamogeton* as the latter becomes available through falling water levels. The reverse occurred when water levels rose. Switching from one diet to another has been recorded in barnacle geese (*Branta leucopsis*) (Drent and Sweirstra 1977) and white-fronted geese (Owen 1971), also related to changing availability, but in this case the result of food depletion, not flooding.

Average Year Use

The 10-year mean water levels at Teslin indicate that, on average, depths level out at between 4.4 and 4.9 m after the initial August decline. From the observations of feeding Canada geese on the delta it would appear that the complex zone is most often used at these levels. Thus, I conclude that, although *Potamogeton* may be the most preferred food

zone on the Nisutlin River delta, the Complex zone probably assumes a greater importance to the geese because the *Potamogeton* zone is less available under average water levels.

IV. NUTRITIONAL VALUE OF FOODS USED BY CANADA GEESE

A. Introduction

Foods selected by waterfowl should reflect the relative nutritional benefits they provide. While on fall staging areas, waterfowl are building up energy reserves (Ankney and MacInnes 1978, Wypkema and Ankney 1979, Thomas and Prevett 1980). Much research, concerned with testing aspects of foraging theory, has treated food consumption in qualitative terms based on gross energy values (Rapport 1971, Pulliam 1974). Pyke *et al.* (1977) indicated that there were limitations to this approach. In order to study the effects of food selection in a natural setting, a measure of the relative benefits of each food type in that setting should be made. The food selected should be the one which produces the greatest relative benefit to the individual. This benefit may be measured as rate of weight change over time.

The concept of food selectivity among wild herbivores has been of interest to ecologists for some time. Several hypotheses have been suggested to explain this observed selectivity. It has been suggested that plant chemistry plays a role in the selection of food by wild herbivores (Bryant and Kuropat 1980). Nutritional quality may be a factor in the selection of different food types. Bevlovsky (1978) found that proximal nutritional quality of browse was a factor in food selection in moose (*Alces alces*). Several people have found that the nutrient content of foods plays a

role in lagomorph food selection (Miller 1968, Lindlof *et al.* 1974) as well as that of gallinaceous birds (Moss 1968, Miller 1968, Gardarsson and Moss 1970, Pulliainen 1970, Moss 1972, Salo 1973). Food selection in waterfowl, and in geese in particular, may also be related to the nutritional benefits gained from the preferred as opposed to the non-preferred foods (Thomas and Prevett 1980). Owen (1975) and Harwood (1977) found that both breeding and wintering geese selected vegetation high in nitrogen content. Because geese are not known to be capable of cellulose digestion (Marriot and Forbes 1970, Mattocks 1971), the major components of plant material that can be assimilated by these birds would be cell contents, including protein and soluble carbohydrates.

Before and during migration, geese probably select those foods that will benefit them the most in terms of weight gain . During fall staging periods individuals apparently attempt to build up energy reserves for the coming migration (Ankney 1977, Thomas and Prevett 1980), and therefore should select for the best possible diet with respect to energy content.

The Canada goose (*Branta canadensis*) population staging on the Nisutlin River delta during the autumn selects from a variety of zones of vegetation and grazes in only a few (Chapter 1). The most preferred food appeared to be the rhizomes of *Potamogeton richardsonii* with a complex zone composed mainly of *Equisetum palustre* and *Ranunculus reptans*

ranked second. The least preferred of the food plants used, *Equisetum fluviatile*, apparently is taken only if rising water levels force the geese out of the other two zones. A very small amount of *Hippuris vulgaris* is also eaten, apparently somewhat opportunistically. For the purposes of this study the *E. fluviatile* area will be referred to as zone A, the Complex as zone B, the *P. richardsonii* as zone C, and the *H. vulgaris* as zone D. If geese staging on this delta establish these preferences according to the organic nutrient content of the foods chosen, one would predict that a similar ranking should appear with preferences and nutrient content.

This chapter examines the benefits accrued to geese grazing on a more and a less-preferred food zone and reports on the nutrient content of foods as well as ranking them for comparison with the preferences shown.

B. Methods

Relative Benefits

To test the relative nutritional values of food plants growing in two zones of vegetations, two groups of tame Canada geese imprinted on humans were used. These geese were raised from eggs collected in the wild near Brooks, Alberta, hatched, and reared until they were 10 weeks old when they were transported to the Yukon. During the period of imprinting they were raised in isolation from other groups

of geese but allowed to graze natural vegetation. The two groups were imprinted in order to control where they were grazed while feeding freely on the delta. Their primaries were also clipped to prevent flight.

The geese were subdivided into two groups, each consisting of six juvenile birds, three of each sex. To avoid the possibility of genetic influence, siblings were not placed in the same group.

Three main feeding zones were used by wild Canada geese on the Nisutlin River delta: zones A, B, and C (Fig. 6). Because of the inaccessibility of zone C in 1983 and the importance of zone B in years of average water levels (chapter 1) the nutritional benefits of grazing in zones A and B were compared. The specific areas where the two groups of geese were grazed are shown in Figure 13.

The geese were allowed to graze freely on the chosen zones for ca 9 hours per day. To determine rate of intake on each zone, a comparison of grazed and ungrazed areas was made every third day from 14 to 22 August. This comparison was done in the following way. The geese were restrained within a 6 m^2 enclosure and allowed to feed for 30 min. Within this enclosure was a 0.5 m^2 exclosure. The standing crop within the exclosure was then compared with an average of two or three representative areas of similar size which the geese had grazed. In this way the rate of food consumption on each zone and total amount per day were estimated. The two groups of geese were allowed to graze on

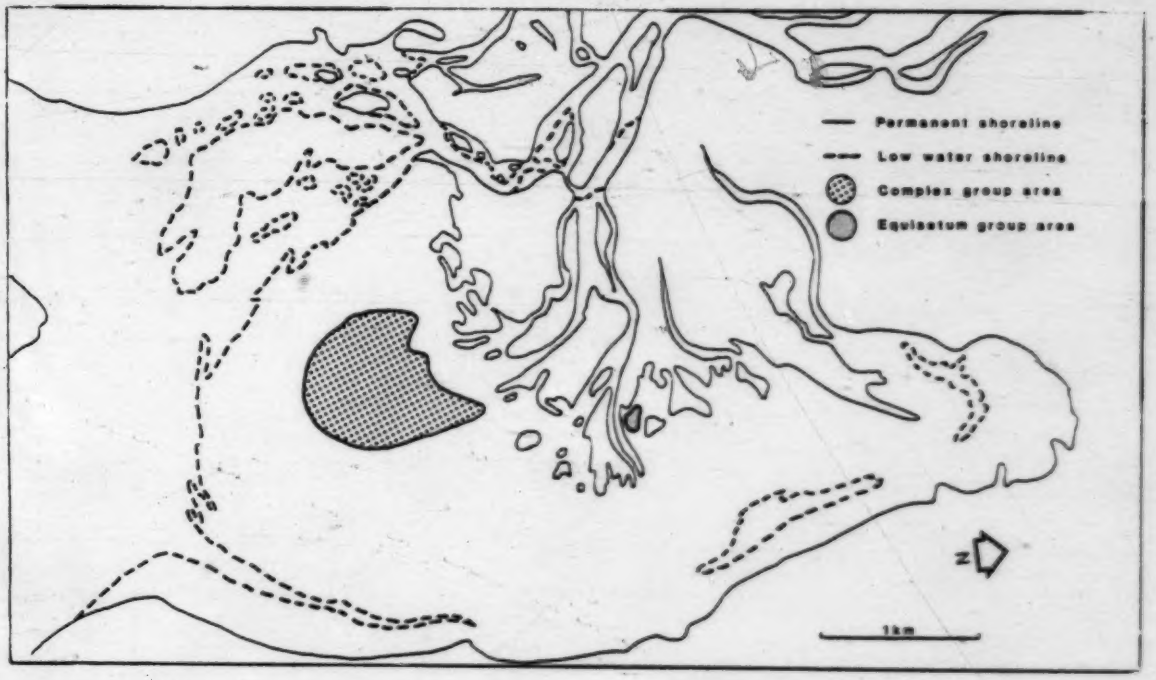

Figure 13. Feeding areas grazed by the two experimental flocks of Canada geese, Nisutlin River delta, August 1983.

the separate areas from August 10 to 24, 1983, and were moved only if they strayed off the specific zone of vegetation assigned for grazing. The birds were weighed with a Pesola 5 kilogram spring balance every morning before being allowed out to graze.

Grazing rate in terms of bites per minute (BPM) were recorded for the geese in the tame groups as well as the wild geese to compare rates of intake. Because the natural population fed mainly in zone B, comparisons were only made between the tame and wild birds in this area.

Nutritional Analysis

Plant samples were collected on the Nisutlin River delta on August 24 of 1983. The wild Canada geese had been arriving in the area since August 1. Five samples of 5g (dry weight) each of *Potamogeton richardsonii* (rhizomes), *Equisetum fluviatile* (shoot), *E. palustre* (shoot), and *Hippuris vulgaris* (rhizome) were collected. *E. palustre* was observed to be the main component of the diet (85%) of geese feeding in zone B ; the remainder was *Ranunculus reptans* (10%) and *Eleocharis palustris* (5%). Ten representative samples containing a mix of the observed food items in zone B, in proportion to their observed use, were also collected for analysis. Sample size was doubled in this case because of potential variability among samples with the three main types of vegetation. The samples were sorted and the dead material rejected as geese are known to select against

non-living plant material (Owen 1972a). The samples were then dried and subjected to nutrient analysis after returning from the field. Fecal samples were collected from the groups of tame geese known to have been feeding on specific zones. Five samples of fecal pellets were collected from geese feeding on *Equisetum fluviatile*, *E. palustre*, and plants in zone B. These samples were dried and preserved for further analysis.

The dried samples were finely ground (60-mesh screen). Analyses were done in duplicate and, when possible, in triplicate. Protein was obtained as the percent nitrogen X 6.25 by Kjeldahl determination as in Marriot and Forbes (1970) and Burton *et al.* (1978). Cellulose and ash for all samples was determined through a neutral-detergent fiber (NDF) procedure which produces a measure of indigestable cell wall constituents (Goering and Soest 1970, Maynard and Loosli 1979). Amount of soluble carbohydrates (cell contents) was determined from the formula: 100-(ash+fiber+crude protein)=percent soluble carbohydrate (Schaible 1976). Proportional uptake of carbohydrates was determined by comparing carbohydrate composition of the plants and feces.

Analysis of BPM and weight change data sets was done using regression analysis and unpaired t-test subprograms of the MINITAB statistical package. Instructions for procedures in this program can be found in Ryan *et al.* (1976).

Protein, total non-structural carbohyrate (TNSC), and fiber levels for the plant samples were compared using a one-way analysis of variance and significance was determined using Sheffe's Multiple Contrast method (Zar 1974) and Students t procedures. The analysis of variance was run on a MINITAB statistical package sub-program. Data sets for the fecal material were analysed by un-paired t test as were comparisons between the plant and fecal material.

C. Results

Relative Benefits

Feeding rates in terms of bites per minute (BPM) for wild geese (n=130) and those in the two tame flocks (n=104 and 86) were examined. These feeding rates were recorded over the course of the day (Fig. 14). No significant differences exist between the mean BPM of the tame and wild flocks grazing on zone B (pooled t, 16df, $P>.75$), however, feeding rates in zone B were significantly greater than in zone A (pooled t, 10df, $P<.0005$). This difference in rate may be related to the ability of the geese to handle and swallow the different foods.

Were amounts eaten per day different in the two zones of vegetations, or was feeding rate compensated for by bite size? The tame geese grazing on zone B ingested an average of 91.80 grams (dry weight) per day whereas the geese feeding in zone A ingested an average of 83.22 grams per

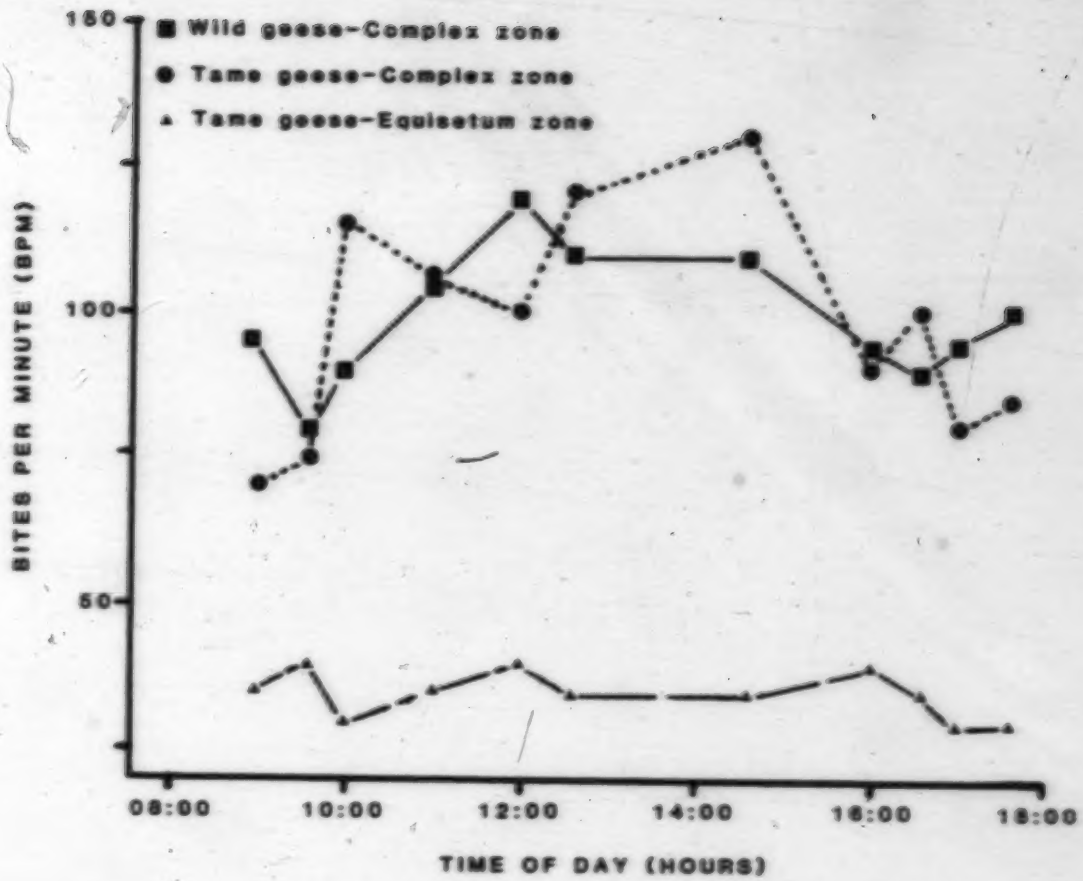

Figure 14. Feeding rate in bites per minute, over a 10-hour period, for three groups of Canada geese.

day. The difference in intake between the two groups was not significant (Table 3). Thus, the bite size or weight of food taken per bite by group A compensated for the smaller number of bites taken. I concluded that, although the two groups had differing rates of intake, this was compensated for by larger bite size in group A and resulted in the two groups ingesting the same weight of food per unit time.

The response, in terms of weight gain, of the two groups grazing on different vegetation was followed over a period of 14 days (Fig. 15). Weights of geese in the two groups of tame birds were similar at the onset of the experiment (Table 4). Weights taken on August 24, when the feeding experiment was ended, showed the birds grazing in zone B were significantly heavier than those grazing in zone A. Mean weights over the 14 weighing periods for the two groups showed a steady increase among those birds grazing in zone B, whereas the weight of those birds grazing in zone A steadily decreased. Members of the group grazing in zone B gained an average of 19.4% of original body weight over the 2-week period, whereas the birds grazing in zone A lost an average of 3.1% of body weight per bird over the same period. The differences in rate of weight change (slopes of the regression lines) were significant, with the geese feeding in zone B having a steeper (positive) slope (Students t, 28df, $P<.0005$) than than for geese feeding in zone A where the slope was negative. The negative weight change shown by the geese feeding in zone A was

Table 3. Ingestion rates of two groups of tame Canada geese grazing in two types of vegetation.

	Weight (g) ingested per hour	
Vegetative zone	Wet weight	Dry weight
Zone A	28.63	9.25
		P=0.58[1]
Zone B	35.60	10.20

1.Difference in means (pooled t, 6df, n=14)

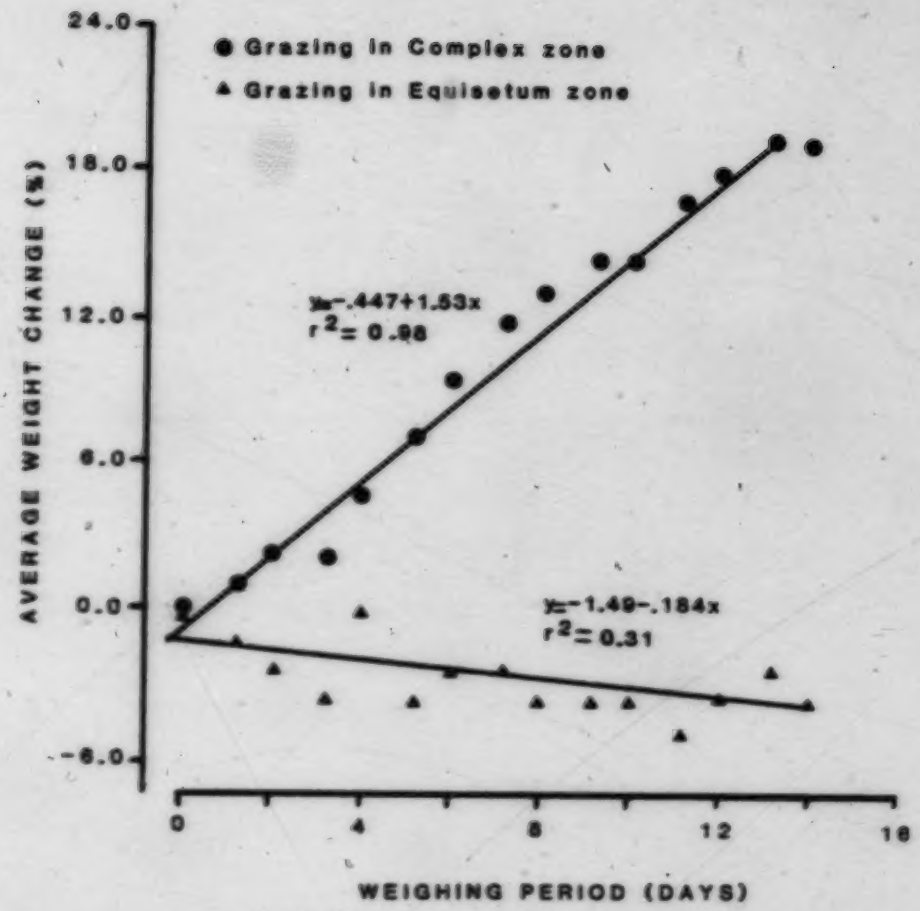

Figure 15. Average daily cumulative weight changes shown by the members of two groups of Canada geese, one feeding in zone A and the other in zone B for a 2-week period.

Table 4. Weights (kg) before and after a 2-week feeding period of two groups of tame Canada geese fed different diets.

	Weight of Geese												
	Complex zone							*Equisetum* zone					
Individual	A.	B.	C.	D.	E.	F.		A.	B.	C.	D.	E.	F.
Sex	M	M	M	F	F	F		M	M	M	F	F.	F
Wt.(Aug 10)	2.80	2.00	2.23	2.91	2.47	2.21	NSD	2.72	2.29	2.04	2.49	2.49	2.43
Wt.(Aug 24)	3.24	2.46	2.84	3.52	2.93	2.74	***	2.53	2.17	2.12	2.46	2.37	2.45

*** P<.005 (students t, 10df)

significantly different than no weight change (F test, 14df, $P<.0005$). There appeared to be no differences in the rate of weight change, actual weight changes, or BPM between males and females within groups.

Nutritional Analysis

Potomageton richardsonii had a significantly lower (half or less) fiber content than all of the other foods ingested (Table 5). It was followed by *E. palustre* which was significantly lower than either *E. fluviatile* or *Hippuris vulgaris*. Fiber content in zone B samples was similar to that of the *Hippuris vulgaris* and *E. fluviatile* samples.

Fiber content of feces did not vary significantly regardless of vegetation zone used. A comparison of fiber levels in input and output of geese grazing in zone B showed no difference (unpaired t, 13df, $P=.1752$). Similar results were seen in comparisons of fiber content of food and feces when considering *E. palustre* (Students t, 8df, $P=.0789$) and *E. fluviatile* (Students t, 8df, $P=.9700$). These values support the assumption that geese do not digest fiber; hence fiber content of feces should be similar or higher than those of foods.

Crude protein content of *E. palustre* was significantly greater than that of all other species tested (Table 5). The other species of horsetail, *E. fluviatile*, had a higher crude protein content than either *P. richardsonii*, *H. vulgaris*, or the combination of species from zone B, whereas

Table 5. Fiber, crude protein, total non-structural carbohydrate (TNSC) content (% dry weight) of food plants and feces of Canada geese feeding on the Nisutlin River delta. Samples taken on August 24, 1983.

Food	N	Fiber	D[1]	Crude Protein	D[1]	TNSC	D[1]	Ash
		Mean±SD						
P. richardsonii	5	13.77±1.72		7.38±1.33		74.38±4.18		4.47
E. palustre	5	26.01±3.00		18.56±0.49		51.28±4.16		4.15
E. fluviatile	5	31.31±2.97		13.64±1.02		52.26±3.62		2.79
Complex zone[2]	10	31.24±7.35		9.66±1.41		34.99±12.10		24.11
H. vulgaris	5	30.37±7.25		9.08±1.33		40.98±6.50		19.57
Feces								
E. palustre	5	37.90±8.26		20.22±9.70		24.01±6.89		17.87
E. fluviatile	5	31.38±2.86		11.60±2.58		41.26±6.01		15.76
Complex zone[2]	5	34.90±2.20		14.14±3.26		33.72±8.26		17.24
Proportional Uptake[3]								
E. palustre						53.2%		
E. fluviatile						21.0%		
"Complex"[2]						3.6%		

1. Based on Sheffe's Multiple Contrast Method. Lines connect only means that are not significantly different.
2. Mixture contained shoots of *Equisetum palustre*, *Ranunculus reptans* and *Eleocharis palustris*.
3. % TNSC content in food -% TNSC content in feces/% TNSC content in food x 100.

P. richardsonii had the lowest level of crude protein content. Protein levels in feces and plants were not compared because of the presence of uric acid in the fecal samples.

Non-structural carbohydrate content of the foods used varied considerably (Table 5). The levels present in *P. richardsonii* were significantly higher than all other food types, whereas the levels in the samples of *Equisetum* were not significantly different but were higher than either the rhizomes of *H. vulgaris* or the zone B samples (Table 5).

The fecal samples showed a significantly lower level of TNSC in *E. palustre* than in *E. fluviatile* (Table 5). In both of these comparisons, the fecal TNSC level was lower than that of the food items. This was not so for a similar comparison of the plants and feces from zone B. Minimal uptake of TNSC for the *E. palustre* was 53.2% of dry weight whereas the same measure in *E. fluviatile* was only 21.0% (Table 5). Digestability of carbohydrates is related to fiber levels of the food plants and hence the more fiberous *E. fluviatile* should be less digestable than the less fiberous *E. palustre* food type. As seen in Table 5, the less digestible components of foods (excluding crude protein because of metabolic waste input), ash and fiber, become more concentrated in the feces, whereas the most digestable component (TNSC) became less concentrated. This signifies that TNSC is removed from foods at a rate reflected by the increase in proportion of non-digestables. The goose foods

tested are ranked according to preference and organic nutrient content in Table 6.

D. Discussion

Relative Benefits

There were no differences in feeding rates between wild and tame geese when using zone B. Thus, it would seem justifiable to extrapolate the results obtained for the tame birds to the wild geese.

Although there were no differences in counts of BPM between wild and tame geese grazing in zone B, differences did exist between the two groups of tame birds. Geese using short vegetation in zone B fed at a higher rate throughout the day than did the birds using tall vegetation in zone A. Feeding rates in white-fronted geese (*Anser a. albifrons*) are reported to be inversly related to vegetation height (Owen 1972a, Drent and Sweirstra 1977). This relationship may also hold on the Nisutlin River delta where the average height of vegetation used on zone B was ca 10 cm, while that in zone A was ca 40 cm. The geese grazing on zone A were ingesting larger plant fragments which may have required more handling time and hence were unable to take as many bites per minute because of this.

The number of BPM by grazing geese appears to vary considerably over the daylight period. Owen (1972a) found a positive linear relationship between time of day and BPM in

Table 6. Ranking of goose food plants growing on the Nisutlin River delta according to preference, fiber content, protein content, and TNSC content.

Food	Preferred Rank[1]	Fiber[2]	Protein[2]	TNSC[3]
P. richardsonii	1	1	1	1
E. palustre	2	2	4	2.5
E. fluviatile	3	3.5	3	2.5
H. vulgaris	4	3.5	2	4

1. Based on a comparison of use and availability of feeding zones (Chapter 1).
2. Ranked from lowest to highest levels.
3. Ranked from highest to lowest levels.

white-fronted geese. A rate of 110 BPM at 10:00 hours, increased to 134 at 17:00 while grazing on a variety of graminoid species. A varying grazing rate is also reported for barnacle geese (*Branta leucopsis*) wintering in The Netherlands; rates varied from 30 BPM in the morning falling to 10 at noon, and then rising up to 160 BPM by 18:00 hours (Ebbinge *et al.* 1977). For the days in which Canada geese grazing rates were sampled, there appeared to be little relationship between time of day and BPM in either the wild or tame geese.

Although the group grazing in zone A had a much lower BPM rate than the Zone B birds, they ingested as much in terms of dry weight per unit time. Any difference in intake between the two groups may be related to the handling time for each food. The height of vegetation may be negatively related to intake because of an increase in handling time when feeding on taller vegetation. This being so, geese grazing in zone B must maintain a much higher number of BPM to sustain similar levels of food intake. The bulk of the plant eaten probably plays a role in amounts ingested per bite and consequently per day. *E. fluviatile* is a large, coarse plant, whereas the main food items in zone B, *E. palustre* and *Ranunculus reptans*, are small and finely structured (Hulten 1968).

Barnacle geese were found to ingest from 29.3 to 52 grams (dry weight) of grasses per day (Ebbinge *et al.* 1977). Although these values are lower than those I obtained for

the Canada geese it must be noted that the smaller barnacle goose average between 1.7 and 2.3 kilograms in weight (Owen, 1980) in contrast to the larger Canada geese which averaged 2.65 kg. per bird at the end of this study. The age and circumstances of the geese in the two studies were also different. The tame Canada geese were juveniles feeding to attain full growth and energy stores for migration, whereas the barnacle geese were fully grown birds on the wintering grounds. The difference in intake in these two studies may also be related to the quality the foods consumed.

The weight changes recorded in the two groups of Canada geese feeding on two types of vegetation have implications for geese staging on the Nisutlin River delta. Because the wild population chooses to graze in zone B rather than zone A (chapter 1), some mechanism of selection must be operating. By confining one tame group to each of the two zones, I was able to test the relative benefits, in terms of weight gain, to grazing geese in the respective zones. On this basis it is obvious that Canada geese would gain more by grazing zone B rather than zone A. The difference in relative benefits of the two food zones probably plays a major role in the ranking of feeding zones on the area. Geese grazing in zone A apparently could not acquire sufficient nutrients from their food to maintain body weight when allowed to graze for 9 hours. Since they were not subjected to energetically demanding activities such as flight, it is probable that the wild population would be at some

considerable energetic disadvantage if forced to feed in zone A for this limited period each day and would select against it if given a choice.

Nutritional Analysis

The most preferred food items of Canada geese staging on the Nisutlin River delta are the rhizomes of *Potamogeton richardsonii* (Chapter 1). When tested for organic nutrients against the four other food types, *Potamogeton* was found to contain the lowest fiber and protein content, but the highest non-structural carbohydrate level. It has been found that geese select foods for high nitrogen levels during wintering and breeding periods (Owen 1975, Harwood 1977), and it is suggested that this is related to the physiological demands of preparation for breeding. It has also been suggested that fall staging geese may benefit from high carbohydrate levels which provide for increased energy demands during migration (Thomas and Prevett 1980). These demands include increased thermoregulatory activity when confronted with decreased ambient temperatures in autumn as well as the deposition of energy reserves in the form of fats before migration occurs. It has been suggested that increased fiber levels decrease the digestability of the soluble carbohydrate component (Thomas and Prevett 1980). As the *Potamogeton* rhizomes contained the least fiber as well as the greatest proportion of carbohydrates, digestability of this plant should be very high. Because TNSC levels are

derived from the formula: 100-(protein+fiber+ash)=TNSC, higher levels of any of these contributing factors would result in a lower TNSC level. As *P. richardsonii* has the lowest fiber and protein components of the species tested, the TNSC of this food would be the highest.

TNSC in foods used by staging geese on James Bay (Thomas and Prevett 1980) and moulting geese at Teshekpuk Lake, Alaska (Derksen *et al.* 1982), are compared with levels found in goose foods during this study in Table 7. TNSC levels of the most preferred food on the Nisutlin River delta appear to compare favourably with levels reported on the James Bay staging area.

Changes in proportion of protein and fiber were negligible for the plant/feces pairs comparison but the proportional uptake of TNSC in the *E. fluviatile* and *E. palustre* samples were significant. The protein levels of fecal material may be artificially high as they contained nitrogenous wastes in addition to non-digested protein. For this reason a valid estimate of protein digestability cannot be made. TNSC uptake was 53.2% for the *E. palustre* plant/fecal samples and 21.0% for the *E. fluviatile* samples. This difference could be explained on the basis of fiber levels in the two plants. *E. fluviatile* has a higher fiber content than does *E. palustre*. This may lead to a decreased TNSC digestability in *E. fluviatile* as explained by Thomas and Prevett (1980). This also may help explain why zone B where the main constituent is *E. palustre* was selected over

Table 7. Comparisons of carbohydrate content of goose foods in three different areas.

Study	N	TNSC content (%dry weight)
James Bay[1]		
Triglochin maritima	10	40±2.5[3]
T. palustris	5	76 (72.3-79.4)[4]
Teshekpuk Lake[2]		
Sedges	2	5.35±2.62[5]
Grasses	4	13.03±4.43[5]
This Study		
Potamogeton richardsonii	5	74.38±4.18[5]
Equisetum palustre	5	51.28±4.16[5]
E. fluviatile	5	52.26±3.62[5]
Hippuris vulgaris	5	40.98±6.50[5]

1. Thomas and Prevett (1980).
2. Derksen *et al.* (1982)
3. Mean±standard error
4. Mean (range)
5. Mean±standard deviation

E. fluviatile on the Nisutlin River delta.

Goose populations may select for different nutrients at different times of the season. When breeding and nesting (and perhaps wintering as well) the birds may be selecting for high protein levels in preparation for reproduction. In the immediate post-breeding period, geese may select for a nutritionally balanced diet in order to provide adequate protein for feather growth, while selecting for increasing amounts of carbohydrates in preparation for migration. As the geese move onto their fall staging grounds, the focus of food selection may shift away from high protein and on to high soluble carbohydrate levels. In order to build up energy in the form of fat reserves, TNSC may become more important to the geese than high protein intake. Late in the season, feather growth may be demanding less input of proteins than immediately following moult and the need for TNSC may become the determining factor in the food selection process. Thus, the foods selected for by the Canada geese staging on the Nisutlin River delta may be those with a greater potential for TNSC uptake.

Fall staging geese are in the process of building up energy reserves for the coming migration to wintering areas (Wypkema and Ankney 1979, Thomas and Prevett 1980). It is to their advantage to select feeding areas that enable them to achieve the greatest energy uptake per unit time while on the staging area. The Nisutlin River delta, one of the rare fall staging areas in the Yukon (Chapter 1), must therefore

provide the resources neccessary for fall migration, and for this reason is a vital link in the annual cycle of this population of Canada geese.

V. GUT MORPHOLOGY OF CANADA GEESE ON DIFFERENT DIETS

A. Introduction

The phenomenon of changing digestive organ size with change in feeding habits of birds has been examined by a number of investigators (Lewin 1963, Pendergast and Boag 1973, Ankney 1977, Burton *et al.* 1979). In gallinaceous birds, Leopold (1953) showed positive correlation between amount of plant forage in the diet and length of gut parts. Lewin (1963) reported that digestive system characteristics varied with changes in fiber content of diet. In the case of Spruce Grouse (*Canachites canadensis*), Pendergast and Boag (1973) also reported that increased biomass of the gastro-intestinal tract was correlated with poorer quality of diet during winter. It was subsequently determined that changes in the length of ceaca was associated with rate of food consumption rather than diet quality per se (Fenna and Boag 1974).

For waterfowl, Miller (1975) reported that food intake and digestive organ size in mallards (*Anas platyrhynchos*) increased when the birds were maintained on a high fiber diet. It was suggested by Ankney (1977) that changes in gut measurements of lesser snow geese (*Chen caerelescens*) were related to total input of food before and during nesting rather than a change in diet quality. Burton *et al.* (1979) found no significant change in ceacum length of snow geese

over a period of changing diet fiber levels and suggested that observed increases in small intestine and gizzard sizes were mechanical adaptations to reduction in diet quality.

Because the population of Canada geese (*Branta canadensis*) staging on the Nisutlin River delta during the fall exhibit food selection (Chapter 1), it was thought that this was related to quality of the preferred foods. The nutritional content of these foods was examined and when allowed to graze on the more preferred foods, a significant increase in body weight was recorded (Chapter 2). However, since the two groups of tame geese had similar rates of food intake when grazing on a high and a low quality diet (Chapter 2), one could predict that no change in size of digestive organs based on the conclusion that organ size is a function of ingestion rates (Penna and Boag 1974). This chapter records the gut characteristics of two groups of Canada geese on two different diets.

B. Methods

Two groups of six tame Canada geese (3 males and 3 females), were allowed to graze on selected vegetation on the Nisutlin River delta (Fig. 13) for a 2-week period during August, 1983. The vegetative zones chosen were used differentially by a wild population of geese (Chapter 1). One group of geese was allowed to graze on the less preferred area which consisted of a virtually pure stand of *Equisetum fluviatile*, the other group grazed on an area of

more preferred vegetation where the major food plants were *Equisetum palustre*, *Ranunculus reptans*, and *Elocharis palustris* (Chapters 1 and 2). These species were observed to be eaten by the geese at a ratio of ca 8.5:1.0:0.5 respectivly. For the purposes of this study the zone of *E. fluviatile* will be referred to as zone A, and the complex vegetation zone will be referred to as zone B.

After a 2-week grazing period the geese were sacrificed and measurements of their digestive organs taken. The geese were sacrificed after a 15-hour fast to ensure a relatively empty digestive tract. The measurements taken were: length of small intestine and ceaca (cm); and weight of gizzard and grit contained within (gm). The weights of gizzard and grit were taken with a 500 gram Pesola spring balance. Lengths were taken with the organ swinging freely and a 50 gram weight attached to the lower end in order to avoid biased measurements.

All analyses of anatomical measurements between groups were done using unpaired t tests following the procedures contained in Zar (1974).

C. Results

Anatomical measurements are shown in Table 8. The raw measurements were divided by original body weight of the individual in order to control for the differing weights of the experimental groups.

Table 8. Actual and standardized digestive organ measurements of two groups of Canada geese fed two different diets over a 2-week period.

		Zone B Group									Zone A Group							
Bird	Sex	Ceacum		Sm. Intestine		Gizzard		Grit		Sex	Ceacum		Sm. Intestine		Gizzard		Grit	
		X	Y	X	Y	X	Y	X	Y		X	Y	X	Y	X	Y	X	Y
AA	M	28.00	10.29	201.0	73.90	158	58.09	16.0	5.88	M	31.85	11.37	212.0	75.51	155	55.35	15.0	5.26
B	M	27.09	10.86	196.0	78.81	139	55.82	19.0	7.63	M	23.45	10.52	191.0	85.87	145	65.02	15.0	6.73
C	M	31.80	12.52	206.0	81.10	142	55.90	13.0	5.12	M	33.80	11.61	215.5	74.05	181	62.20	20.0	6.87
D	F	28.95	12.64	195.5	85.37	121	52.84	14.0	6.11	F	24.75	11.80	184.0	92.00	124	62.00	9.0	4.50
E	F	27.40	13.43	188.5	92.40	138	67.65	10.0	4.90	F	29.35	11.88	194.5	78.74	165	66.80	10.0	4.05
F	F	31.80	10.64	184.0	73.90	140	56.22	15.0	6.02	F	33.05	14.95	207.0	93.66	141	63.80	9.0	4.07
MEAN		29.71	11.73	195.2	80.91	140	57.75	14.5	5.94		29.37	12.02	200.6	83.34	152	62.53	13.0	5.26
SD		1.94	1.29	7.32	7.14	10.7	5.13	2.75	0.96		3.99	1.52	11.68	8.41	18.1	3.95	4.04	1.28

X. Actual anatomical measurement.
Y. Measurement/Original body weight.

Because I found no differences in measurements within sexes between groups, they were pooled when comparing sexes. Grit weight (t-test, 9df, P=.0081) and corrected grit weight (t-test, 9df, P=.0169) was lower in females than males. As there were no differences between sexes within groups, I pooled them for the comparisons between groups.

I found no significant differences for either lengths of small intestine (P=.5711) or ceaca (P=.5494) between the two groups.

The only differences recorded regarding digestive organ size in the experimental groups were those of proportion of body weight devoted to digestive organs. The group that fed in zone A weighed less than the group that fed in zone B at the termination of the study (Chapter 2). Since there were no significant differences in digestive organ size between the two groups, the zone A group carried a higher amount of body mass in the form of digestive organs (Table 9).

Ceacal length was correlated with body weight (r=0.57,P<.05) of the two groups as was gizzard weight (r=0.85,P<.001). Of the other measurements, small intestine length showed a tendency to be related to body weight (r=0.48,P>.10). Grit weight was uncorrelated with body weight.

Table 9. Proportion of body weight devoted to digestive organs in two groups of Canada geese.

Measurement	Zone B Group						Zone A Group					
Length(cm/kg)	A.	B.	C.	D.	E.	F.	A.	B.	C.	D.	E.	F.
Ceaca(total/2)	11.06	11.41	12.25	13.34	12.92	10.77	9.38	8.36	9.57	10.06	10.02	12.06
Sm. Intestine Weight(g/kg)	74.45	82.70	84.05	90.09	88.91	74.80	65.43	67.43	61.05	74.80	66.38	73.55
Grit	.63	.80	.53	.64	.47	.61	.46	.53	.57	.37	.34	.33
Gizzard	6.24	5.86	5.80	5.58	6.51	5.69	4.78	5.11	5.13	5.04	5.63	5.15

D. Discussion

Because I found no differences between sexes in gut measurements, I feel justified in grouping them for comparisons. Similar results were found in digestive organ sizes between male and female mallards (*Anas platyrhynchos*) within two groups fed on two different diets (Miller 1975).

Weights

Because similar rates of intake were seen in the two groups of tame Canada geese, no difference in weight of gizzards was expected and none was seen. Gizzard weights of snow geese (*Chen c. caerulescens*) did increase in response to a lowering of diet quality (Burton *et al.* 1979) but their study was done over a much longer period of time than this one and was associated with a change in rate of intake by the geese over that period.

Lengths

Although it has been found that lengths of small intestines may increase with a decrease in diet quality (Savoury and Gentel 1976, Burton *et al.* 1979), it has been suggested that this adaptation is a result of premigratory hyperphagia (Kirkpatrick 1944, Anderson 1974, Ankney 1977). Once again, most of the aforementioned studies were longer term ones and the geese in this study may not have had the time to show structural adaptations. It has been found in gallinaceous birds that the length of the ceaca may increase with an

increased level of fiber in the diet (Pendergast and Boag 1973, Savoury and Gentel 1976). Because these birds are known to be cellulose digesters (Gasaway 1975), the increase in ceaca size is not surprising as this is the main site of cellulitic digestion (Moss and Parkison 1972, 1975). It does not appear that geese possess the ability to digest cellulose (Marriot and Forbes 1970, Mattocks 1971). Thus, the ceaca of the two study groups would not have been expected to increase in length in response to a poor quality diet. Burton *et al.* (1979) found a significant difference in the length of small intestines in snow geese during a change to a highly fibrous diet but they found no difference in ceacal length. No differences were found for the two groups in this study in either gizzard ($p=.1126$) or grit weight ($p=.7282$). Gizzard weight was found to be significantly increased in lesser snow geese feeding on a more fibrous diet by Burton *et al.* (1979) as well. Small intestine length and gizzard weight were found to be greater in mallards fed a more fibrous diet by Miller (1975). All of the aforementioned studies were associated with differing rates of intake and this is probably related to the structural adaptations seen in the digestive tract.

VI. CONCLUDING DISCUSSION

Fall staging geese are preparing for the last stage of the autumn migration. This preparation would appear to be served by selecting foods that provide them with the most nutrients in the shortest possible time. In this selection, many factors come into play.

The availability of the most beneficial food may affect the selection process. As seen on the Nisutlin River delta, availability of the preferred food was dependent upon water levels on the staging area (Chapter 1). Availability may also depend upon the quantity of the preferred foods relative to the size of the populations using them. If the preferred foods are depleted, then a feeding group must necessarily make a choice between the other available food types. This sort of successive depletion has been found to be a factor in food selection by geese in a number of studies (Owen 1971, Drent and Sweirstra 1977). Disturbance by man may also lead to a food becoming unavailable to a goose population (Owen 1972b). Other factors such as agricultural use of staging areas and extreme weather conditions may result in geese depending upon less than optimal diets (Phillipona 1966, Owen 1972b).

Nutrient content of food is another factor influencing the resource selection process of geese. The nutritional requirement for maintenance functions must be met as well as those for future events. These future events may include egg production or gonadal enlargement in the nesting and

pre-nesting periods. It has been found that certain nutrients are required by breeding waterfowl in order for these reproductive processes to occur (Ankney 1977). Protein levels of food have been found to be important in food selection of wintering, breeding, and post-breeding geese (Owen 1971, 1975, Harwood 1977). Non-structural carbohydrates have been found to be a major component of preferred foods for fall staging geese (Thomas and Prevett 1980, Chapter 2). High carbohydrate intake may be neccessary during pre-migratory periods as this nutrient is related to high energy storage in the form of body fat deposits (Maynard and Loosli 1979). The determining factor in food selection on fall staging areas may be high soluble carbohydrate levels rather than high protein levels. The more preferred foods on the Nisutlin River delta have either high carbohydrate content and low fiber levels or higher potential carbohydrate digestibility as compared to the less preferred food types (Chapter 2).

As seen in Chapter 2, relative benefits of two food types on the Nisutlin River delta are striking. The food type more preferred by the Canada goose population staging on the Nisutlin River delta was apparently much more beneficial to the physical condition of geese than less preferred foods. Relative benefits may also play a role in selection of food zones by the goose population. If given a choice of these two food zones, it would be to the advantage of the birds to choose the one with the greatest relative

benefits. This decision is crucial at a time when the geese are in preparation for the rigors of migration.

The phenomenon of changing digestive organ sizes in response to a change in quality of diet was not found to be a relevant factor in the two food zones compared on the Nisutlin River delta (Chapter 3). Fiber levels in the two food types used, may have had an influence upon any adaptations to these diets. The fiber levels of the two diets were found to be equal (Chapter 2). As fiber content was found to be one of the determining factors in digestive structural adaptations (Lewin 1963, Miller 1975), one would not suspect any structural differences between birds fed on diets equal in fiber content. It was also found that the geese ingested similar amounts of food per unit time and so would not develop different digestive organ sizes in relation to higher or lower rates of intake.

In optimal foraging theory, food or food patch selection is related to the location of patches and energy expended to obtain the use of them (Pulliam 1974, Pyke *et al.* 1977). The "cost" of a food in terms of energy to obtain it would necessarily be less than the energy obtained from a patch if it were to be used as a food source. If less energy is required to move to a certain food patch than to another, the former becomes more desirable (if the foods are identical in benefits to the selecting organism).

Selection of food zones by the staging Canada geese on the Nisutlin River delta may be examined using the optimal

patch model. The food zones located closer to the roosting area of the geese may be more attractive than the ones at a greater distance because they require less energy expenditure in terms of flight requirments to locate and use. As seen in Chapter 1, the more preferred zones tended to be the ones requiring less flight energy to use. Although it was seen that the more preferred zones also were the more beneficial in terms of nutrient content and weight gains, the closeness to the roost may have been an added incentive for the geese to select them. The roosting area on the Nisutlin River delta was located on a mud flat surrounded by water, even when water levels are at their lowest. It is more likely that this site was chosen because of its island status than because of the closeness to the preferred zones. It may be coincidental that the zone closest to the roosting area is the most preferred.

The opportunity to study Canada geese staging on the Nisutlin River delta area is unique in the field of waterfowl ecology. Staging areas in the Pacific northwest are, for the most part, rare, because of the topography of the region. Fall staging areas in eastern Canada, and particularly on Hudson and James Bays, cover a very large area and observation of the foraging behaviors of an entire staging population would be extremely difficult. The numbers of Canada geese in the Yukon are sufficiently small that the Nisutlin River delta may provide a staging area for the majority of inland birds breeding south of the Ogilvie

Mountains. Geese breeding north of this mountain range generally follow migration routes that skirt the Nisutlin area (Jarvis and Bartonek 1979, Owen 1980). Because of the rarity of suitable staging areas in this region, the Nisutlin River delta becomes an important link in the life cycles of a great number of the waterfowl species in the Yukon. Very little work has been done on fall staging Canada geese, particularly in this region. For these reasons this study assumes added importance.

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VIII. APPENDIX I

Measurements of Nisutlin River delta Canada Geese

Sex	M	M	M	M	M	M	M	F	F	F	F	F	F
Age	HY	HY	HY	HY	HY	HY	HY	AHY	HY	HY	HY	HY	HY
Weight	3.29	3.03	3.02	3.29			2.90	3.10		3.40	3.06	3.03	2.13
Culmen	41	50	48	45	49	45	43	45	39	51	43	49	40
Nares[a]	23	26	23	25	23	25	25	23	21	23	22	25	20
Nares[b]	32	38	34	34	32	32	35	33	30	34	33	37	29
Width[c]	22	22	22	29	22	23	24	21	19	25	22	23	20
Tarsus	99	103	105	99	104	105	105	99	95	98	92	98	93
M. Toe	85	99	97	99	94	93	92	91	80	87	86	87	79
Wing Chord	447	446	442	450	466	479		447	441	455	436	420	437
Bill to Sternum	395	394	424	402	411	372	387	366	301	350	385	376	343
Total length	812	812	870	831	842		811	802	742	783	809	767	737

All measurements are in mm excepting weight (kg.)

a. Measurement from front of nares to tip of nail.

b. Measurement from back of nares to tip of nail.

c. Width of bill at back of nares.

HY Hatch year bird

AHY After hatch year (Adult)